NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE 2389

FATIGUE STRENGTHS OF AIRCRAFT MATERIALS

AXIAL-LOAD FATIGUE TESTS ON NOTCHED SHEET SPECIMENS OF 24S-T3 AND 75S-T6 ALUMINUM ALLOYS AND OF SAE 4130 STEEL WITH STRESS-CONCENTRATION FACTORS OF 2.0 AND 4.0

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SUMMARY

This report presents results of axial-load fatigue tests on notched specimens of three sheet materials: 24S-T3 and 75S-T6 aluminum alloys and normalized SAE 4130 steel. Notches included:

(1) Stress-concentration factor 2.0: Central circular hole, symmetrical edge notches, and fillets

(2) Stress-concentration factor 4.0: Symmetrical edge notches and fillets

For each type of specimen, fatigue tests were run at several levels of nominal mean stress, including a zero nominal mean stress.

Fatigue strengths for these notched specimens are compared with values previously reported for unnotched specimens of the same sheet materials.

INTRODUCTION

This is the second of a series of reports summarizing work on an investigation of the fatigue strengths of metals used in aircraft construction. The investigation, conducted at Battelle Memorial Institute, under the sponsorship and with the financial assistance of the National Advisory Committee for Aeronautics, has the objective of obtaining extensive basic data on the fatigue properties of three widely used sheet materials: 24S-T3 and 75S-T6 aluminum alloys and SAE 4130 steel.

The previous report (reference 1) presented data on unnotched specimens. Such data are of interest in regard to basic properties of the materials, but are not adequate for design of structural parts. Structures nearly always have necessary stress-raisers, such as holes, cutouts, or other sharp changes in section that are critical in fatigue. Accordingly, the investigation was extended to study the behavior of notched specimens of the three sheet materials. The present report presents the results of fatigue tests on sheet specimens with several types of notches.

The notch forms used were chosen in an effort to obtain systematic information covering several variables which might influence notch fatigue strength. Two notch severities, judged by the theoretical stress-concentration factor K_t, were used: $K_t = 2.0$ and $K_t = 4.0$. For the lower severity, notches of three different shapes (fillets, edge notches, and a circular hole) were selected; for the higher severity, two shapes (fillets and edge notches) were used. These different notch forms afford variation not only in stress-concentration factor but also in stress gradient and in volume of highly stressed material near the notch.

Some of the results presented in the first report are recapitulated in the present report to allow discussion of fatigue-strength reduction caused by the various notch forms.

The authors wish to thank Mr. Paul Kuhn, of the Structures Research Division of the Langley Aeronautical Laboratory of the NACA at Langley Field, Virginia, for his help and guidance during this investigation, and Mr. David O. Leeser, formerly on the staff of Battelle Memorial Institute, who did most of the experimental work described in this report.

EXPERIMENTAL PROCEDURES

Material

The materials used in this investigation were supplied from selected stock retained for this purpose at the Langley Aeronautical Laboratory of the NACA. Coupons were cut from 0.090-inch-thick commercial sheets of 24S-T3 and of 75S-T6 aluminum alloys and from 0.075-inch-thick commercial sheets of normalized SAE 4130 steel. Details of sheet layout are to be found in reference 1.

Static-strength properties, some of which are repeated from the previous report, are given in table 1.

Notched Specimens

Figures 1 and 2 show dimensional drawings of the notched specimens. Notch dimensions were chosen, on the basis of information available in the literature and unpublished information from the Langley Aeronautical Laboratory, to produce theoretical stress-concentration factors of 2.0 and 4.0. Notches were cut with tools specially machined to produce the contour desired in each case. Machining cuts were successively lighter, so that the depth of each of the last two cuts was about 0.0005 inch. Following machining, specimens were finished by electropolishing, which removed an average of about 0.0003 inch from the surface in the region of the notch and left a surface estimated to have about an 8-microinch profilometer value. Specimens were shadowgraphed after electropolishing: The dimensions and tolerances in figures 1 and 2 are those actually measured. It was estimated that errors in K_t due to variation in notch dimensions were not greater than those due to uncertainties in theoretical and photoelastic information on which notch design was based.

Figures 3 and 4 show stress-coat patterns obtained on some of the notched specimens under tensile loading. These patterns indicate stress distributions such as would be expected from the theory of elasticity.

Table 1 contains static-failure strengths for the notched specimens. Nominal tensile stresses at failure were not greatly different from values of ultimate tensile strength determined by tests on standard tensile specimens. Thus, stress-concentration effects of the notches were apparently alleviated by plastic deformation before static failure occurred.

Fatigue Test Procedures

Fatigue tests were run on Krouse direct repeated-stress testing machines at speeds in the range 1100 to 1500 cycles per minute. A description of the machines is given in reference 1. It is estimated that precision of load measurement and maintenance was about ±3 percent in tension-tension tests. In tests involving reversal of load, sheet specimens were restrained from buckling by the use of guide plates. Estimation of precision of loading in such cases was indirect; it is believed that error in load value, in reversed-load testing, did not usually exceed ±5 percent.

FATIGUE TEST RESULTS

Results of axial-load fatigue tests are given in tables 2 to 7. These results are plotted in the form of S-N diagrams in figures 5 to 10. All stress values indicated on these diagrams are nominal net-area stresses. While the data are insufficient to afford a statistical evaluation of scatter, it may be noted that observed points fall closely on the S-N curves drawn.

Figures 11 to 25 show the same results plotted in another manner: As constant-lifetime diagrams of nominal stress amplitude plotted against nominal mean stress. In these diagrams, however, "points" are not directly observed values but are values read from the faired S-N curves in figures 5 to 10.

DISCUSSION OF RESULTS

Diagrams such as those shown in figures 11 to 25 have been suggested for use in design. However, the designer encounters a great variety of notch forms and will seldom be concerned with one exactly like any used in this or any other laboratory fatigue investigation. Consequently, there is considerable interest in attempting to understand the notch fatigue behavior of a material sufficiently that results of a limited number of tests may be generalized to apply to the great variety of notch forms and loading conditions encountered in aircraft service.

Tables 8 to 10 summarize fatigue-strength values for notched specimens, and include corresponding values previously reported for unnotched specimens of the same sheet materials. The following discussion is based on values listed in these summary tables.

In view of the local nature of fatigue failure, it is expected that the fatigue strength of a notched specimen will be strongly influenced by stress concentration at the root of the notch. Thus, it seems desirable to examine the results of notch fatigue tests in terms of estimated peak stress at the notch root. Conventionally, such examination is usually made in terms of a "fatigue-strength reduction factor," denoted by K_f, and defined as the ratio of unnotched fatigue strength to notched fatigue strength. While such a definition is unambiguous for test runs under fully reversed load, further specification is needed when the mean load differs from zero. At least three definitions of K_f have been advocated for such cases:

(1) Load-ratio definition,

$$K_f \equiv \frac{\text{Maximum stress for unnotched specimen}}{\text{Nominal maximum stress for notched specimen at same load ratio and lifetime}}$$

(2) Load-amplitude definition,

$$K_f' \equiv \frac{\text{Stress amplitude for unnotched specimen}}{\text{Nominal stress amplitude for notched specimen at same nominal mean stress and lifetime}}$$

(3) Maximum load at fixed mean load definition,

$$K_f'' \equiv \frac{\text{Maximum stress for unnotched specimen}}{\text{Nominal maximum stress for notched specimen at same nominal mean stress and lifetime}}$$

Calculations of K_f, K_f', and K_f'', for the values listed in tables 8, 9, and 10, show that none of these three fatigue-strength reduction factors are constant for the full range of notch forms and stress levels covered in this investigation. In general, K_f and K_f'' are less than K_t, while K_f' sometimes exceeds K_t. Design, based on the approximation that any one of these K_f's is predictable from the theoretical stress-concentration factor of the notch or even upon the assumtpion that a K_f (like one of the three defined here) is constant over a range of stress levels, might be seriously in error.

Consideration of the probable peak stress at the notch root, in relation to the stress levels at which fatigue failures occur, indicates one reason for this lack of simple correlation between K_f and K_t. For a great deal of the region of stress, plastic flow undoubtedly occurred at the point of highest stress. It will be convenient, in further discussion, to treat, first, low stress levels for which such plastic flow may be negligible and, second, the remaining part of the stress field investigated.

Region of Low Maximum Stress

In the region of low stresses and little plastic flow, the peak stress at the root of a notch should be given by K_t times the nominal stress to which the notched specimen is loaded. Thus, at low stress levels, one might expect, insofar as fatigue failure depends on maximum stress, that a notched specimen under a cycle from a nominal minimum stress m_n to a nominal maximum stress M_n would fail in the same lifetime as an unnotched specimen under a cycle from minimum stress $K_t m_n$ to maximum stress $K_t M_n$. In this case, the "load-ratio fatigue-strength reduction factor" K_f should equal K_t through this low-stress region.

Examination of tables 11, 12, and 13 shows that K_f usually approaches K_t in regions of low maximum stress. However, even in such regions, K_f is often less than K_t, particularly for the more severe notches ($K_t = 4$). Neuber (reference 2) suggests that departures from elastic theory should be expected in notches so sharp that stress gradients are large over regions of local inhomogeneity and anisotropy of the material under investigation. He proposes using a "technical stress-concentration factor," defined by

$$K_N = 1 + \frac{K_t - 1}{1 + \sqrt{\frac{\rho'}{\rho}}} \tag{1}$$

In this defining equation, ρ is the radius of the notch, and ρ' is a constant (with the dimension of length) of the material. Neuber suggests that the value of ρ' may be about 0.02 inch for many materials. Table 14 shows values of K_N for the notches used in this investigation for several values of ρ'. Comparing these values with values of K_f in tables 11, 12, and 13, it appears that K_f is often nearer to K_N (for $\rho' = 0.02$ in.) than to K_t. No other value of ρ' affords much better agreement for all values of K_f.

Thus, results obtained in low-stress-level fatigue tests on the notched sheet specimens are approximately predictable by assuming $K_f = K_N$. However, until the limitations of this assumption are more completely established, such predictions should be used with caution in design of notched parts.

Region of High Maximum Stress

Figure 26 is a schematic illustration of effects likely to occur in tension-tension tests in which the maximum stress is high enough to cause local yielding at the notch root. Two effects are to be noted:

(1) At the top of the load cycle, the maximum local stress is less than $K_t M_n$; that is, local deformation alleviates the stress concentration predicted for ideally elastic material

(2) Upon unloading to minimum load, residual stress at the notch root decreases the minimum local stress below that expected for ideally elastic behavior

Both of these effects have been observed experimentally (references 3 to 7). Some time ago, Hartmann (reference 8) suggested an approximate method of estimating the alleviation of the stress-concentration factor at maximum load; Stowell (reference 4) has recently suggested another method of approximating the local maximum stress. No satisfactory method of theoretically estimating the residual stress and the resultant minimum local stress has been reported.

For fully reversed loading through large stress amplitudes, additional complications may occur. In this case, local yielding may take place both during tensile loading and during compressive loading. Cumulative strain hardening may alter the behavior during successive load cycles. Behavior in this region is too complex for prediction on the basis of currently available information.

If this picture of fatigue-strength reduction at high stress levels is correct, it would be expected that the stress ratio would differ from the load ratio, and that K_f would differ from K_t (or from K_N). In fact, it appears doubtful that any simply defined fatigue-strength reduction ratio could be expected to remain constant over the full range of stress levels. It is possible that detailed consideration of effects of plastic deformation and residual stresses will afford approximate rules useful in design.

CONCLUSIONS

Axial-load fatigue test results have been obtained on notched sheet specimens of 24S-T3 and 75S-T6 aluminum alloys and of SAE 4130 steel. Several notch forms were used and tests were run at several levels of mean stress. The results show that:

1. Reduction in fatigue strength (in terms of nominal stresses) varies with:

(a) Notch severity (theoretical stress-concentration factor)

(b) Notch form, especially for severe notches

(c) Material

(d) Stress level - both nominal mean stress and nominal stress amplitude

2. Simply defined fatigue-strength reduction factors do not appear to have useful correlation with the theoretical stress-concentration factor.

Battelle Memorial Institute
Columbus, Ohio, August 15, 1950

REFERENCES

1. Grover, H. J., Bishop, S. M., and Jackson, L. R.: Fatigue Strengths of Aircraft Materials - Axial-Load Fatigue Tests on Unnotched Sheet Specimens of 24S-T3 and 75S-T6 Aluminum Alloys and of SAE 4130 Steel. NACA TN 2324, 1951.

2. Neuber, H.: Theory of Notch Stresses: Principles for Exact Stress Calculation. Translation 74, The David W. Taylor Model Basin, U. S. Navy, Nov. 1945.

3. Griffith, George E.: Experimental Investigation of the Effects of Plastic Flow in a Tension Panel with a Circular Hole. NACA TN 1705, 1948.

4. Stowell, Elbridge Z.: Stress and Strain Concentration at a Circular Hole in an Infinite Plate. NACA TN 2073, 1950.

5. Norton, J. T., and Rosenthal, D.: Investigation of the Behavior of Residual Stresses under External Load and Their Effect on Safety. The Welding Jour., vol. 22, no. 2, Feb. 1943, pp. 63-s - 78-s.

6. Rosenthal, D., Sines, G. H., and Zizicas, G.: The Effect of Residual Compression on Fatigue. The Welding Jour., vol. 28, no. 3, March 1949, pp. 98-s - 103-s.

7. Sines, G. H.: The Effect of Residual Stress upon the Fatigue of Notched Specimens. Master's Thesis, Univ. of Calif., July 1949.

8. Hartmann, E. C.: Fatigue Test Results - Their Use in Design Calculations. Product Engineering, vol. 12, no. 2, Feb. 1941, pp. 74-78.

TABLE 1.- STATIC TENSILE AND COMPRESSIVE STRENGTHS OF SOME ALUMINUM AND STEEL SHEET SPECIMENS USED IN FATIGUE TESTS

Material	Grain direction	Type specimen	Average tensile properties (a)			Average compressive properties (a)	
			Elongation (percent)	Yield strength (psi)	Ultimate strength (psi)	Yield strength (psi)	Modulus of elasticity (psi)
24S-T3	With	Unnotched	18.2	54,000	73,000	44,500	10.65×10^6
24S-T3	Cross	Unnotched	18.3	50,000	71,000	50,000	10.45
24S-T3	With	Hole-type notch (K_t = 2.0)	-----	-------	71,500	------	----------
24S-T3	With	Fillet-type notch (K_t = 2.0)	-----	-------	72,000	------	----------
24S-T3	With	Edge-cut notch (K_t = 2.0)	-----	-------	74,500	------	----------
24S-T3	With	Fillet-type notch (K_t = 4.0)	-----	-------	65,900	------	----------
24S-T3	With	Edge-cut notch (K_t = 4.0)	-----	-------	65,400	------	----------
75S-T6	With	Unnotched	11.4	76,000	82,500	74,000	10.45
75S-T6	Cross	Unnotched	11.0	75,000	82,500	78,500	10.55
75S-T6	With	Hole-type notch (K_t = 2.0)	-----	-------	80,500	------	----------
75S-T6	With	Fillet-type notch (K_t = 2.0)	-----	-------	82,500	------	----------
75S-T6	With	Edge-cut notch (K_t = 2.0)	-----	-------	87,500	------	----------
75S-T6	With	Fillet-type notch (K_t = 4.0)	-----	-------	80,000	------	----------
75S-T6	With	Edge-cut notch (K_t = 4.0)	-----	-------	82,500	------	----------
4130	With	Unnotched	14.25	98,500	117,000	86,000	30.4
4130	Cross	Unnotched	12.5	101,000	120,000	97,000	31.3
4130	With	Hole-type notch (K_t = 2.0)	-----	-------	120,500	------	----------
4130	With	Fillet-type notch (K_t = 2.0)	-----	-------	119,000	------	----------
4130	With	Edge-cut notch (K_t = 2.0)	-----	-------	[b]117,000	------	----------
4130	With	Fillet-type notch (K_t = 4.0)	-----	-------	119,000	------	----------
4130	With	Edge-cut notch (K_t = 4.0)	-----	-------	129,000	------	----------

[a]Values for unnotched specimens taken from reference 1. All stress values nominal, based on original net section.

[b]Specimen failed in grip section at load noted.

TABLE 2.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 24S-T3 ALUMINUM SHEET SPECIMENS; NOTCHED, $K_t = 2.0$

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(a) Nominal mean stress, 0 psi			
Hole-type notch			
A27S2C	34,000	2,500	
A65S2C	28,000	17,500	
A10S2C	24,000	28,800	
A9S2C	20,000	70,000	
A15S2C	15,000	405,000	
A20S2C	12,000	>10,907,000	Did not fail
A18S2C	10,000	>10,994,800	Do.
Edge-cut notch			
A79S2B	35,000	3,400	
A84S2B	35,000	3,500	
A73S3B	30,000	6,500	
A80S3B	30,000	7,700	
A30S2B	28,000	------------	Buckled
A88S2B	25,000	17,400	
A29S2B	20,000	70,000	
A73S2B	15,000	754,000	
A35S2B	15,000	160,000	Failed in grip
A40S2B	15,000	210,000	
A1S2B	13,500	287,000	Failed in flaw
A74S3B	11,000	>10,586,000	Did not fail
Fillet-type notch			
A40S2A	30,000	10,000	
A39S2A	22,500	64,000	
A73S2A	18,000	233,000	
A34S2A	15,000	500,000	
A78S2A	12,000	5,251,800	

[1]Unless otherwise noted, specimens failed at notch root in region of critical stress concentration.

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TABLE 2.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 24S-T3 ALUMINUM

SHEET SPECIMENS; NOTCHED, $K_t = 2.0$ - Continued

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(b) Nominal mean stress, 10,000 psi			
Hole-type notch			
A28S2C	46,000	2,700	
A12S2C	43,000	5,500	
A53S2C	40,000	6,100	
A51S2C	35,000	16,500	
A63S2C	35,000	17,100	
A62S2C	30,000	30,100	
A54S2C	30,000	36,200	
A55S2C	25,000	118,000	
A59S2C	22,000	283,700	
A58S2C	20,000	542,700	
A57S2C	19,000	181,400	Failed in flaw
A14S2C	19,000	5,564,300	
A24S2C	18,500	6,568,100	
A22S2C	18,000	>13,013,200	Did not fail
Edge-cut notch			
A75S3B	44,000	2,900	
A87S3B	44,000	3,000	
A47S2B	40,000	6,500	
A77S2B	35,000	14,900	
A46S2B	35,000	15,500	
A45S2B	30,000	35,000	
A32S2B	30,000	43,400	
A74S2B	25,000	124,200	
A79S2B	22,000	168,700	
A38S2B	21,000	507,400	
A83S2B	20,000	7,687,400	
A81S2B	19,000	>15,018,800	Did not fail
Fillet-type notch			
A87S2A	43,000	4,000	
A71S2A	40,000	6,500	
A44S2A	35,000	27,100	
A80S2A	35,000	30,000	
A77S2A	30,000	73,200	
A33S2A	30,000	75,100	
A88S2A	25,000	129,200	
A81S2A	22,500	288,100	
A85S2A	22,000	283,200	
A82S2A	20,000	>10,486,700	Did not fail

[1]Unless otherwise noted, specimens failed at notch root in region of critical stress concentration.

TABLE 2.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 24S-T3 ALUMINUM

SHEET SPECIMENS; NOTCHED, K_t = 2.0 - Continued

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(c) Nominal mean stress, 20,000 psi			
Hole-type notch			
A26S2C	52,500	2,300	
A19S2C	52,500	4,000	
A16S2C	52,500	3,000	
A61S2C	49,000	7,100	
A96S2C	45,000	15,600	
A52S2C	40,000	35,600	
A100S2C	35,000	75,400	
A91S2C	31,000	213,200	
A49S2C	29,500	2,319,700	
A56S2C	29,500	9,536,000	
A95S2C	27,500	>10,936,000	Did not fail
Edge-cut notch			
A84S2B	52,500	3,100	
A85S3B	49,000	9,300	
A70S2B	49,000	6,000	
A42S2B	45,000	21,800	
A91S2B	45,000	25,300	
A78S2B	40,000	48,300	
A80S2B	35,000	66,500	
A93S2B	35,000	82,200	
A90S2B	31,500	28,200	Failed in flaw
A82S2B	31,000	128,500	
A85S2B	31,000	218,700	
A71S2B	29,500	>13,114,700	Failed lower grip
A89S2B	27,500	>15,671,300	Did not fail
Fillet-type notch			
A79S2A	52,500	4,500	
A83S2A	49,000	8,300	
A89S2A	45,000	19,800	
A40S2A	40,000	30,300	
A92S2A	35,000	67,000	
A96S2A	31,500	595,400	
A69S2A	29,500	1,042,400	
A70S2A	29,500	>10,305,000	Did not fail
A94S2A	27,500	>12,693,800	Do.

[1]Unless otherwise noted, specimens failed at notch root in region of critical stress concentration.

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TABLE 2.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 24S-T3 ALUMINUM SHEET SPECIMENS; NOTCHED, $K_t = 2.0$ - Concluded

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(d) Nominal mean stress, 30,000 psi			
Hole-type notch			
A17S2C	60,000	2,000	
A23S2C	54,000	14,000	
A50S2C	50,000	21,800	
A67S2C	45,000	55,700	
A21S2C	42,500	68,500	
A66S2C	40,000	243,800	
A64S2C	39,000	395,700	
A68S2C	38,000	>12,000,600	Did not fail
Edge-cut notch			
A70S3B	60,000	4,300	
A81S3B	60,000	4,500	
A83S2B	54,000	9,600	
A44S2B	50,000	25,700	
A71S3B	50,000	25,700	
A48S2B	45,000	63,500	
A34S2B	42,500	152,900	
A36S2B	40,000	259,200	
A87S2B	40,000	315,500	
A37S2B	38,500	>10,537,100	Did not fail
Fillet-type notch			
A29S2A	54,000	17,600	
A32S2A	50,000	29,200	
A48S2A	45,000	47,000	
A43S2A	45,000	95,300	
A38S2A	42,500	114,600	
A47S2A	40,000	173,200	
A36S2A	39,000	>10,608,000	Did not fail
A45S2A	38,000	>11,541,600	Do.

[1]Unless otherwise noted, specimens failed at notch root in region of critical stress concentration.

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TABLE 3.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 24S-T3 ALUMINUM

SHEET SPECIMENS; NOTCHED, $K_t = 4.0$

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(a) Nominal mean stress, 0 psi			
Edge-cut notch			
A10S3B	22,500	3,200	
A47S3B	17,500	10,000	
A9S3B	12,500	53,400	
A5S3B	10,000	121,500	
A34S3B	7,500	1,256,700	
A44S3B	7,000	6,309,100	
A43S3B	8,000	944,400	
A50S3B	5,000	>11,169,000	Did not fail
Fillet-type notch			
A11S3A	25,000	4,400	
A16S3A	20,000	15,000	
A30S3A	15,500	38,500	
A14S3A	12,500	140,100	
A46S3A	9,500	1,066,000	
A50S3A	9,500	548,700	
A40S3A	7,500	>10,969,000	Did not fail
(b) Nominal mean stress, 10,000 psi			
Edge-cut notch			
A26S3B	30,000	2,000	
A38S3B	30,000	4,000	
A31S3B	27,500	3,000	
A45S3B	27,500	5,700	
A40S3B	25,000	12,000	
A33S3B	22,500	26,000	
A24S3B	20,000	52,000	
A21S3B	20,000	62,500	
A15S3B	17,500	71,000	
A18S3B	17,500	61,500	
A3S3B	16,500	112,000	
A28S3B	15,000	>10,533,800	Did not fail
A11S3B	15,000	>10,408,300	Do.
Fillet-type notch			
A41S3A	35,000	2,500	
A19S3A	32,500	3,100	
A13S3A	32,500	2,800	
A39S3A	30,000	6,500	
A9S3A	27,500	12,000	
A2S3A	25,000	25,500	
A3S3A	22,500	49,800	
A44S3A	20,000	87,000	
A42S3A	17,500	653,700	
A6S3A	15,000	>10,733,000	Did not fail

[1]Unless otherwise noted, specimens failed in notch root in region of critical stress concentration.

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TABLE 3.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 24S-T3 ALUMINUM

SHEET SPECIMENS; NOTCHED, $K_t = 4.0$ - Concluded

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(c) Nominal mean stress, 20,000 psi			
Edge-cut notch			
A12S3B	35,000	3,700	
A29S3B	32,500	9,000	
A49S3B	30,000	26,600	
A16S3B	27,500	39,400	
A37S3B	25,000	1,343,000	
A13S3B	22,500	>10,321,500	Did not fail
Fillet-type notch			
A17S3A	40,000	4,000	
A48S3A	37,500	6,000	
A35S3A	35,000	10,200	
A38S3A	32,500	15,500	
A25S3A	30,000	21,000	
A4S3A	30,000	44,500	
A22S3A	27,500	69,800	
A5S3A	27,500	80,000	
A49S3A	27,500	161,500	
A36S3A	25,000	300,000	
A10S3A	25,000	5,797,000	
A33S3A	22,500	>10,213,000	Did not fail
(d) Nominal mean stress, 30,000 psi			
Edge-cut notch			
A46S3B	47,500	2,200	
A42S3B	45,000	4,000	
A17S3B	42,500	7,000	
A32S3B	40,000	14,000	
A20S3B	37,500	24,500	
A39S3B	35,000	124,500	
A30S3B	32,500	>10,450,000	Did not fail
Fillet-type notch			
A21S3A	47,500	3,300	
A8S3A	45,000	7,500	
A31S3A	42,500	11,500	
A29S3A	40,000	26,700	
A24S3A	37,500	61,000	
A47S3A	35,000	413,700	
A15S3A	32,500	>10,703,000	Did not fail

[1]Unless otherwise noted, specimens failed in notch root in region of critical stress concentration.

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TABLE 4.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 75S-T6 ALUMINUM SHEET SPECIMENS; NOTCHED, $K_t = 2.0$

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(a) Nominal mean stress, 0 psi			
Hole-type notch			
B79S2C	36,000	3,400	
B100S2C	34,000	3,200	
B99S2C	28,000	14,000	
B94S2C	24,000	42,000	
B95S2C	21,000	86,000	
B86S2C	18,000	412,400	
B91S2C	16,000	1,028,000	
Edge-cut notch			
B100S3B	34,000	5,500	
B95S3B	34,000	5,400	
B50S2B	34,000	4,000	
B93S3B	30,000	------------	Buckled
B92S3B	30,000	12,000	
B47S2B	30,000	11,400	
B44S2B	28,000	19,000	
B45S3B	24,000	23,700	
B26S2B	21,000	89,000	
B6S2B	18,000	213,000	
B17S2B	15,000	347,500	
B28S2B	15,000	579,000	Failed in grip
B10S2B	15,000	1,564,300	
B43S2B	12,500	>10,853,500	Did not fail
Fillet-type notch			
B45S2A	34,000	10,000	
B42S2A	34,000	11,500	
B35S2A	34,000	------------	Buckled
B28S2A	31,000	13,300	
B30S2A	31,000	14,600	
B10S2A	28,000	------------	Buckled
B37S2A	28,000	20,000	
B17S2A	24,000	39,700	
B22S2A	21,000	80,000	
B23S2A	18,000	115,000	
B14S2A	15,000	4,541,800	

[1] Unless otherwise noted, specimens failed in notch root at region of critical stress concentration.

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TABLE 4.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 75S-T6 ALUMINUM SHEET SPECIMENS; NOTCHED, $K_t = 2.0$ - Continued

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(c) Nominal mean stress, 20,000 psi			
Hole-type notch			
B74S2C	56,000	2,200	
B85S2C	55,000	3,000	
B48S2C	50,000	5,400	
B58S2C	45,000	9,300	
B57S2C	40,000	12,000	
B72S2C	35,000	29,500	
B66S2C	32,000	46,000	
B67S2C	30,000	165,600	
B93S2C	29,000	536,100	
B96S2C	28,000	>11,250,000	Did not fail
Edge-cut notch			
B21S2B	56,000	2,100	
B97S3B	54,000	3,200	
B3S2B	50,000	5,000	
B14S2B	45,000	11,500	
B40S2B	40,000	13,400	
B11S2B	35,000	28,000	
B12S2B	32,500	76,800	
B27S2B	30,000	621,900	
B23S2B	29,000	>284,000	Failed above lower grip
B18S2B	28,000	>10,781,700	Did not fail
Fillet-type notch			
B11S2A	54,000	5,400	
B6S2A	50,000	9,000	
B1S2A	45,000	17,500	
B2S2A	40,000	18,500	
B19S2A	35,000	33,500	
B43S2A	32,500	53,000	
B13S2A	30,000	105,000	
B34S2A	29,000	>10,249,900	Did not fail

[1]Unless otherwise noted, specimens failed in notch root in region of critical stress concentration.

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TABLE 4.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 75S-T6 ALUMINUM SHEET SPECIMENS; NOTCHED, $K_t = 2.0$ - Continued

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(b) Nominal mean stress, 10,000 psi			
Hole-type notch			
B73S2C	46,600	2,600	
B75S2C	46,500	2,700	
B71S2C	45,000	3,100	
B60S2C	40,000	6,800	
B65S2C	35,000	13,000	
B70S2C	30,000	22,500	
B92S2C	25,000	60,700	
B68S2C	22,000	227,700	
B59S2C	20,500	>12,710,400	Did not fail
B69S2C	20,000	>10,547,800	Do.
Edge-cut notch			
B4S2B	45,000	3,000	
B25S2B	40,000	7,000	
B19S2B	35,000	18,500	
B7S2B	30,000	46,200	
B29S2B	25,000	242,000	
B12S2B	23,500	2,678,600	
B33S2B	22,500	627,500	Failed in upper grip
B34S2B	22,500	>10,581,900	Did not fail
B5S2B	20,500	>12,653,200	Do.
Fillet-type notch			
B12S2A	45,750	5,800	
B31S2A	40,000	13,500	
B44S2A	35,000	20,500	
B41S2A	30,000	59,900	
B7S2A	25,000	189,600	
B16S2A	22,500	718,500	Failed in upper grip
B26S2A	22,500	2,998,000	
B27S2A	21,000	>10,336,900	Did not fail

[1]Unless otherwise noted, specimens failed in notch root in region of critical stress concentration.

TABLE 4.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 75S-T6 ALUMINUM SHEET SPECIMENS; NOTCHED, K_t = 2.0 - Concluded

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(d) Nominal mean stress, 30,000 psi			
	Hole-type notch		
B63S2C	68,000	1,800	
B76S2C	66,100	2,400	
B64S2C	65,000	2,200	
B83S2C	60,000	5,200	
B97S2C	55,000	7,500	
B87S2C	50,000	12,000	
B88S2C	45,000	24,800	
B98S2C	42,500	42,800	
B62S2C	39,000	198,200	
B61S2C	38,000	527,300	
B56S2C	37,000	>10,112,300	Did not fail
Edge-cut notch			
B39S2B	66,500	2,800	
B53S2B	63,000	2,300	
B22S2B	60,000	4,100	
B45S2B	55,000	8,300	
B31S2B	50,000	12,500	
B30S2B	45,000	24,000	
B36S2B	42,500	35,000	
B35S2B	39,000	81,000	
B15S2B	38,000	>10,062,700	Did not fail
B16S2B	37,000	>10,363,600	
Fillet-type notch			
B3S2A	65,000	4,800	
B15S2A	60,000	8,000	
B4S2A	55,000	8,700	
B20S2A	50,000	11,500	
B36S2A	45,000	27,000	
B38S2A	42,500	36,000	
B39S2A	40,000	89,000	
B5S2A	38,000	>9,978,500	Failed in upper grip

[1]Unless otherwise noted, specimens failed in notch root in region of critical stress concentration.

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TABLE 5.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 75S-T6 ALUMINUM

SHEET SPECIMENS; NOTCHED, $K_t = 4.0$

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(a) Nominal mean stress, 0 psi			
Edge-cut notch			
B45S3B	20,000	5,300	
B10S3B	16,250	17,800	
B35S3B	12,500	70,000	
B36S3B	9,250	339,200	
B19S3B	8,500	969,200	
B28S3B	7,500	1,652,300	
B20S3B	7,500	4,722,000	
B31S3B	5,500	>12,405,300	Did not fail
B29S3B	4,000	>10,247,800	Do.
Fillet-type notch			
B3S3A	22,500	8,200	
B48S3A	20,000	17,000	
B26S3A	16,250	63,500	
B39S3A	12,500	182,000	
B31S3A	10,000	4,400,000	
B43S3A	9,000	3,097,100	Failed in flaw
B45S3A	7,500	>10,244,500	Did not fail
(b) Nominal mean stress, 10,000 psi			
Edge-cut notch			
B16S3B	30,000	2,000	
B26S3B	25,000	8,000	
B38S3B	22,500	13,000	
B17S3B	20,000	41,000	
B23S3B	20,000	39,000	
B1S3B	20,000	32,000	
B4S3B	17,500	48,500	
B8S3B	15,000	89,000	Failed in flaw
B41S3B	15,000	9,610,300	
B43S3B	12,500	>12,281,600	Did not fail
Fillet-type notch			
B15S3A	30,000	4,000	
B38S3A	27,500	10,000	
B5S3A	25,000	14,500	
B4S3A	22,500	45,800	
B21S3A	22,500	39,500	
B16S3A	20,000	39,000	Buckled
B49S3A	20,000	43,000	Do.
B33S3A	20,000	140,000	
B37S3A	20,000	82,500	
B13S3A	17,500	1,676,000	
B27S3A	15,000	>10,000,000	Did not fail

[1]Unless otherwise noted, specimens failed at notch root in region of critical stress concentration.

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TABLE 5.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 75S-T6 ALUMINUM

SHEET SPECIMENS; NOTCHED, $K_t = 4.0$ - Concluded

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(c) Nominal mean stress, 20,000 psi			
Edge-cut notch			
B21S3B	35,000	2,500	
B25S3B	32,500	5,500	
B11S3B	30,000	10,500	
B9S3B	30,000	10,700	
B37S3B	27,500	16,800	
B48S3B	25,000	46,500	
B6S3B	22,500	566,500	
B40S3B	22,500	>10,457,000	Did not fail
Fillet-type notch			
B29S3A	35,000	4,000	
B47S3A	32,500	9,800	
B25S3A	30,000	18,700	
B40S3A	27,500	31,000	
B34S3A	25,000	467,000	
B24S3A	22,500	>9,475,000	Did not fail
(d) Nominal mean stress, 30,000 psi			
Edge-cut notch			
B7S3B	42,500	4,000	
B25S3B	40,000	10,000	
B13S3B	40,000	7,800	
B14S3B	37,500	15,000	
B3S3B	35,000	32,700	
B47S3B	32,500	>10,744,000	Did not fail
Fillet-type notch			
B17S3A	45,000	3,500	
B32S3A	42,500	6,300	
B14S3A	40,000	12,300	
B9S3A	37,500	22,000	
B20S3A	35,000	119,000	
B11S3A	32,500	>10,000,000	Did not fail

[1]Unless otherwise noted, specimens failed at notch root in region of critical stress concentration.

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TABLE 6.- AXIAL-LOAD FATIGUE TEST RESULTS FOR SAE 4130 STEEL

SHEET SPECIMENS; NOTCHED, $K_t = 2.0$

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(a) Nominal mean stress, 0 psi			
Hole-type notch			
C62S2C	45,000	40,700	
C61S2C	38,000	86,000	
C60S2C	32,000	291,000	
C99S2C	28,500	1,083,600	
C56S2C	25,000	>11,429,000	Did not fail
C59S2C	25,000	>12,347,800	Do.
Edge-cut notch			
C51S2B	50,000	27,000	
C197S2B	50,000	35,000	
C82B	45,000	43,000	Failed in grip
C15S2B	45,000	-----------	Specimen buckled
C9S2B	45,000	45,700	
C13S2B	38,000	82,000	
C32S2B	32,000	635,000	
C14S2B	28,500	1,712,700	
C45S2B	25,000	>10,464,300	Did not fail
C33S2B	25,000	>10,900,000	Do.
C47S2B	27,000	2,153,500	
C50S2B	50,000	-----------	Failed in grip
C49S2B	50,000	-----------	Do.
Fillet-type notch			
C40S2A	45,000	53,000	
C29S2A	38,000	147,600	
C42S2A	32,000	628,500	
C25S2A	28,000	1,616,000	
C26S2A	25,000	>10,468,400	Did not fail
C13S2A	50,000	29,000	

[1]Unless otherwise noted, specimens failed at notch root in region of critical stress concentration.

TABLE 6.- AXIAL-LOAD FATIGUE TEST RESULTS FOR SAE 4130 STEEL

SHEET SPECIMENS; NOTCHED, $K_t = 2.0$ - Continued

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(b) Nominal mean stress, 10,000 psi			
Hole-type notch			
C86S2C	57,500	30,700	
C100S2C	55,000	34,000	
C92S2C	50,000	98,000	
C84S2C	45,000	222,000	
C63S2C	40,000	822,000	
C94S2C	37,500	1,452,700	
C83S2C	35,000	>10,043,000	Did not fail
Edge-cut notch			
C46S2B	60,000	28,500	
C48S2B	60,000	31,300	
CXXXXS2B	57,500	31,500	
C43S2B	57,500	31,700	
C31S2B	55,000	55,900	
C30S2B	50,000	93,000	
CXS2B	45,000	151,000	
C4S2B	40,000	255,000	
C39S2B	40,000	290,000	
C38S2B	40,000	421,000	
C44S2B	37,500	900,000	
C35S2B	37,500	1,101,600	
C31S2B	35,000	540,000	Failed in flaw
C2S2B	35,000	>10,608,600	Did not fail
Fillet-type notch			
C34S2A	60,000	------------	Specimen buckled
C11S2A	57,500	36,000	
C16S2A	55,000	45,800	
C32S2A	50,000	103,000	
C28S2A	45,000	235,000	
C10S2A	40,000	545,000	
C27S2A	37,500	1,157,000	
C2S2A	35,000	>10,497,300	Did not fail

[1]Unless otherwise noted, specimens failed at notch root in region of critical stress concentration.

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TABLE 6.- AXIAL-LOAD FATIGUE TEST RESULTS FOR SAE 4130 STEEL

SHEET SPECIMENS; NOTCHED, $K_t = 2.0$ - Continued

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(c) Nominal mean stress, 20,000 psi			
Hole-type notch			
C67S2C	65,000	31,000	
C78S2C	60,000	62,000	
C66S2C	55,000	175,000	
C68S2C	50,000	517,000	
C81S2C	47,500	857,600	
C75S2C	45,000	1,184,700	
C76S2C	42,500	>10,240,400	Did not fail
Edge-cut notch			
C199S2B	72,500	18,000	
C189S2B	70,000	24,500	
C34S2B	70,000	28,000	
C22S2B	65,000	39,700	
C27S2B	60,000	70,900	
C20S2B	55,000	227,000	
C11S2B	50,000	535,900	
C36S2B	47,500	1,002,000	
C7S2B	45,000	1,557,700	
C12S2B	45,000	>1,528,000	Failed in upper grip
C42S2B	42,500	>10,480,300	Did not fail
Fillet-type notch			
C35S2A	70,000	33,300	
C24S2A	65,000	48,000	
C8S2A	60,000	102,000	
C36S2A	55,000	296,000	
C41S2A	50,000	708,000	
C15S2A	47,500	884,900	
C38S2A	47,500	583,000	Failed in pit
C17S2A	45,000	821,500	Do.
C5S2A	45,000	>10,583,700	Did not fail
C22S2A	42,500	>11,013,000	Do.

[1]Unless otherwise noted, specimens failed at notch root in region of critical stress concentration.

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TABLE 6.- AXIAL-LOAD FATIGUE TEST RESULTS FOR SAE 4130 STEEL

SHEET SPECIMENS; NOTCHED, $K_t = 2.0$ - Concluded

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(d) Nominal mean stress, 30,000 psi			
Hole-type notch			
C79S2C	75,000	36,000	
C97S2C	75,000	38,500	
C77S2C	70,000	60,000	
C70S2C	65,000	128,000	
C74S2C	60,000	287,600	
C72S2C	60,000	104,800	1/2-in. crack in flaw
C80S2C	55,000	610,600	
C73S2C	52,500	>10,824,600	Did not fail
Edge-cut notch			
C37S2B	80,000	26,000	
C188S2B	80,000	27,800	
C194S2B	80,000	28,600	
C29S2B	75,000	38,000	
C28S2B	70,000	58,000	
C18S2B	65,000	151,600	
C24S2B	60,000	402,400	
C33S2B	57,500	>10,262,800	Did not fail
C19S2B	55,000	>10,218,900	Did not fail
Fillet-type notch			
C41S2A	75,000	31,000	
C18S2A	75,000	21,000	
C31S2A	75,000	46,500	
C33S2A	70,000	80,000	
C30S2A	65,000	138,000	
C9S2A	60,000	357,000	
C23S2A	57,500	179,100	Failed in flaw
C4S2A	57,500	252,400	
C39S2A	57,500	333,700	
C21S2A	57,500	289,700	
C43S2A	55,000	>10,729,000	Did not fail

[1]Unless otherwise noted, specimens failed at notch root in region of critical stress concentration.

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TABLE 7.- AXIAL-LOAD FATIGUE TEST RESULTS FOR SAE 4130 STEEL

SHEET SPECIMENS; NOTCHED, $K_t = 4.0$

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(a) Nominal mean stress, 0 psi			
Edge-cut notch			
C149S2B	42,500	5,400	Specimen buckled
C104S2B	42,500	14,800	
C111S2B	37,500	19,700	
C144S2B	37,000	19,000	
C130S2B	32,500	30,500	
C125S2B	27,500	107,000	
C38S2B	27,000	94,300	
C115S2B	22,500	269,000	
C122S2B	17,500	537,900	
C142S2B	15,000	1,719,000	
C146S2B	12,500	>10,325,000	Did not fail
Fillet-type notch			
C190S3Z	45,000	4,400	Specimen buckled
C189S3A	45,000	13,500	
C194S3A	40,000	2,000	Specimen buckled
C191S3A	40,000	22,700	
C54S2A	35,000	43,800	
C133S2A	32,500	40,500	
C48S2A	30,000	141,000	
C200S2A	25,000	335,700	
C111S2A	20,000	761,000	
C49S2A	17,500	2,900,000	
C51S2A	16,250	>13,103,000	Did not fail
(b) Nominal mean stress, 10,000 psi			
Edge-cut notch			
C143S2B	50,000	12,600	
C111S2B	50,000	9,000	
C108S2B	42,500	30,700	
C113S2B	38,750	37,000	
C107S2B	35,000	82,000	
C145S2B	30,000	197,000	
C101S2B	27,500	223,000	
C138S2B	27,500	344,000	
C134S2B	25,000	740,000	
C116S2B	22,500	>10,037,000	Did not fail
Fillet-type notch			
C104S2A	50,000	19,000	
C148S2A	42,500	52,000	
C145S2A	38,750	84,500	
C183S3A	37,500	92,500	
C133S3A	35,000	158,000	
C149S2A	32,500	334,000	
C139S2A	30,000	570,000	
C108S2A	27,500	1,425,000	
C103S2A	25,000	>10,327,800	Did not fail

[1]Unless otherwise noted, specimens failed at notch root in region of critical stress concentration.

TABLE 7.- AXIAL-LOAD FATIGUE TEST RESULTS FOR SAE 4130 STEEL SHEET SPECIMENS; NOTCHED, $K_t = 4.0$ - Concluded

Specimen	Nominal maximum stress (psi)	Life (cycles)	Remarks (1)
(c) Nominal mean stress, 20,000 psi			
Edge-cut notch			
C112S2B	57,500	11,400	
C147S2B	55,000	18,000	
C135S2B	51,250	27,000	
C129S2B	45,000	59,000	
C137S2B	40,000	106,000	
C106S2B	37,500	134,000	
C118S2B	35,000	202,000	
C150S2B	35,000	181,500	
C105S2B	35,000	164,000	
C103S2B	32,500	>10,287,000	Did not fail
C132S2B	32,500	>10,000,000	Do.
Fillet-type notch			
C114S2A	57,500	23,000	
C129S2A	51,250	53,300	
C109S2A	45,000	106,000	
C120S2A	40,000	449,000	
C196S2A	40,000	225,000	
C127S2A	37,500	433,000	
C131S2A	35,000	>10,041,000	Did not fail
(d) Nominal mean stress, 30,000 psi			
Edge-cut notch			
C121S2B	65,000	10,000	
C126S2B	60,000	16,500	
C141S2B	55,000	26,500	
C139S2B	52,500	43,000	
C124S2B	50,000	64,000	
C131S2B	47,500	100,000	
C136S2B	45,000	262,000	
C114S2B	42,500	>10,035,500	Did not fail
Fillet-type notch			
C130S2A	72,500	9,000	
C150S2A	65,000	22,500	
C135S2A	60,000	34,500	
C124S2A	55,000	80,000	
C122S2A	50,000	168,000	
C121S2A	47,500	173,000	
C123S2A	45,000	>12,105,000	Did not fail

[1]Unless otherwise noted, specimens failed at notch root in region of critical stress concentration.

TABLE 8.- SUMMARY OF NOTCH FATIGUE TEST RESULTS FOR

24S-T3 ALUMINUM SHEET SPECIMENS

Nominal mean stress (psi)	Notch type	K_t	Nominal maximum stress[1] (psi) for lifetimes (cycles) of -							
			10^3	5×10^3	10^4	5×10^4	10^5	5×10^5	10^6	10^7
0×10^3	None	1	----------	54×10^3	50×10^3	42×10^3	34×10^3	28×10^3	24×10^3	22×10^3
	Hole	2	----------	33	29.5	21	16.5	15	14	12
	Edge	2	$(40) \times 10^3$	33	29.5	21	16.5	15	14	12
	Fillet	2	----------	(35)	32	24	19	15	14	12
	Edge	4	(26)	21	18	12.5	10	8	7.5	7
	Fillet	4	(30)	24	22	13.5	12	10	9.5	9
10	None	1	----------	----------	60	47	41	32	30.5	29
	Hole	2	(50)	42	37	28	25.5	21	20.5	20
	Edge	2	(50)	42	38	29	25.5	21.5	21	21
	Fillet	2	(50)	43	39	32.5	28	22	22	21
	Edge	4	(32.5)	28.5	25	20	16	15.5	15	15
	Fillet	4	(37)	32	28	22	20	17.5	16.5	16
20	None	1	----------	----------	65	53	46	39.5	39	38
	Hole	2	----------	52	47	37	34	30	29	28
	Edge	2	(55)	52	48	38	34	30	30	30
	Fillet	2	(60)	53	48	38	36	31	30.5	30
	Edge	4	(38)	35	32	27	25	25	24	24
	Fillet	4	(43)	38	35	29	27	25.5	25	25
30	None	1	----------	----------	70	59	54	48	47	46
	Hole	2	----------	(58)	55	45	42	39	38	38
	Edge	2	(60)	59	56	47	43	39.5	39	39
	Fillet	2	----------	(60)	57	47	44	39.5	39	39
	Edge	4	(48)	45	41	36	35	34	34	34
	Fillet	4	(50)	46.5	43	38	36	35	34.5	34

[1]Parentheses indicate value obtained by extrapolation.

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TABLE 9.- SUMMARY OF NOTCH FATIGUE TEST RESULTS FOR

75S-T6 ALUMINUM SHEET SPECIMENS

Nominal mean stress (psi)	Notch type	K_t	Nominal maximum stress[1] (psi) for lifetimes (cycles) of -							
			10^3	5×10^3	10^4	5×10^4	10^5	5×10^5	10^6	10^7
0×10^3	None	1	----------	----------	53×10^3	41×10^3	35×10^3	32.5×10^3	32×10^3	30×10^3
	Hole	2	$(37) \times 10^3$	33×10^3	30	24	20	17	16.5	15.5
	Edge	2	(40)	35	31	24	20	17.5	16.5	15.5
	Fillet	2	----------	(37)	34	24	20	17.5	16.5	15.5
	Edge	4	(23)	20	17	13	11	8.5	8	7.5
	Fillet	4	(26)	23.5	22	16.5	14	11	10.5	9.5
10	None	1	----------	----------	62	47	40	39	36	35
	Hole	2	(50)	42	37	26	24	22	21	21
	Edge	2	(50)	42	38	29.5	26.5	24.5	23.5	23
	Fillet	2	(52)	45	42	30	26.5	26.5	23.5	23
	Edge	4	(32)	27	23	18	16	15	14	14
	Fillet	4	(34)	29	26	22	20	18	17	17
20	None	1	----------	----------	70	52	45	43	42	41
	Hole	2	(60)	50	45	32.5	31	29.5	29	29
	Edge	2	(60)	50	46	33	32	30	29.5	29.5
	Fillet	2	(62)	55	49	33	32	30	30	30
	Edge	4	(37)	33	31	25	24	23	23	23
	Fillet	4	(38)	34	32	27	26	24.5	24	24
30	None	1	----------	----------	75	58.5	54	50	49	49
	Hole	2	(70)	59.5	52	42	39.5	37.5	37	37
	Edge	2	(70)	59.5	53	42	39.5	38.5	38.5	38.5
	Fillet	2	(70)	65	54	42	40	38.5	38.5	38.5
	Edge	4	(47)	42	39	34	34	33	33	33
	Fillet	4	(48)	43	40	36	35	34	34	34

[1]Parentheses indicate value obtained by extrapolation.

TABLE 10.- SUMMARY OF NOTCH FATIGUE TEST RESULTS FOR

SAE 4130 STEEL SHEET SPECIMENS

Nominal mean stress (psi)	Notch type	K_t	Nominal maximum stress[1] (psi) for lifetimes (cycles) of -					
			10^4	5×10^4	10^5	5×10^5	10^6	10^7
0×10^3	None	1	75×10^3	65×10^3	63×10^3	55×10^3	52×10^3	47×10^3
	Hole	2	(53)	42	38	31	28	25
	Edge	2	(55)	44.5	40	33	30	27
	Fillet	2	(56)	45	40	33	30	27
	Edge	4	45	32	27	19	16	14
	Fillet	4	47	35	31	23	20	17
10	None	1	87	79	73	68	60	60
	Hole	2	(63)	54	50	41.5	39	35
	Edge	2	(64)	54	50	41.5	39	37
	Fillet	2	(66)	55	51	42	39.5	37
	Edge	4	52	38	34	25	23	23
	Fillet	4	57	43	38	31	27.5	26
20	None	1	95	87	81	75	68	68
	Hole	2	(74)	65	59	50	46	44
	Edge	2	(76)	65	60	50	47	45
	Fillet	2	(80)	66	61	51	47	47
	Edge	4	58	45	41	34	34	33
	Fillet	4	63	51	46	37.5	36	36
30	None	1	103	93	89	82	76	76
	Hole	2	(84)	71	68	57	55	55
	Edge	2	(85)	72	69	58	57	57
	Fillet	2	(87)	73	69	58	57	57
	Edge	4	64	52	49	44	44	43
	Fillet	4	72	57	53	46	46	46

[1]Parentheses indicate value obtained by extrapolation.

TABLE 11.- FATIGUE-STRENGTH REDUCTION FACTORS

FOR 24S-T3 ALUMINUM SHEET SPECIMENS

AT LOW STRESS LEVELS

Notch type	Load ratio	Fatigue-strength reduction factor, K_f, at lifetimes (cycles) of -				
		5×10^4	10^5	5×10^5	10^6	10^7
(a) For notches having $K_t = 2.0$ and for nominal maximum stress <27,000 psi						
Hole	-1.00	2.0	2.1	1.9	1.8	1.8
Edge	-1.00	2.0	2.1	1.9	1.8	1.8
Fillet	-1.00	1.8	1.8	1.9	1.8	1.8
Hole	-.50	---	1.9	1.8	1.8	1.8
Edge	-.50	---	1.9	1.8	1.8	1.8
Fillet	-.50	---	1.8	1.7	1.8	1.8
(b) For notches having $K_t = 4.0$ and for nominal maximum stress <13,500 psi						
Edge	-1.00	3.4	3.4	3.5	3.2	3.1
Fillet	-1.00	3.1	2.8	2.8	2.5	2.4
Edge	-.50	---	3.3	3.2	3.2	3.1
Fillet	-.50	---	---	2.4	2.4	2.4

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TABLE 12.- FATIGUE-STRENGTH REDUCTION FACTORS

FOR 75S-T6 ALUMINUM SHEET SPECIMENS

AT LOW STRESS LEVELS

Notch type	Load ratio	Fatigue-strength reduction factor, K_f, at lifetimes (cycles) of -					
		10^4	5×10^4	10^5	5×10^5	10^6	10^7
(a) For notches having $K_t = 2.0$ and for nominal maximum stress <38,000 psi							
Hole	-1.00	1.8	1.7	1.8	1.9	1.9	1.9
Edge	-1.00	1.7	1.7	1.8	1.9	1.9	1.9
Fillet	-1.00	1.6	1.7	1.8	1.9	1.9	1.9
Hole	-.50	----	1.8	1.9	1.9	1.9	1.9
Edge	-.50	----	1.7	1.8	1.8	1.8	1.8
Fillet	-.50	----	1.7	1.8	1.8	1.8	1.8
(b) For notches having $K_t = 4.0$ and for nominal maximum stress <19,000 psi							
Edge	-1.00	3.1	3.2	3.2	3.8	4.0	4.0
Fillet	-1.00	----	2.5	2.5	2.9	3.1	3.2
Edge	-.50	----	3.0	3.3	3.8	4.0	4.0
Fillet	-.50	----	2.6	2.6	2.8	3.0	3.1

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TABLE 13.- FATIGUE-STRENGTH REDUCTION FACTORS

FOR SAE 4130 STEEL SHEET SPECIMENS

AT LOW STRESS LEVELS

Notch type	Load ratio	Fatigue-strength reduction factor, K_f, at lifetimes (cycles) of -				
		5×10^4	10^5	5×10^5	10^6	10^7
(a) For notches having K_t = 2.0 and for nominal maximum stress <49,250 psi						
Hole	-1.00	1.5	1.7	1.8	1.9	1.9
Edge	-1.00	1.5	1.6	1.7	1.7	1.7
Fillet	-1.00	1.4	1.6	1.7	1.7	1.7
Hole	-.50	---	1.6	1.8	1.9	1.8
Edge	-.50	---	1.6	1.7	1.9	1.8
Fillet	-.50	---	1.6	1.7	1.9	1.8
(b) For notches having K_t = 4.0 and for nominal maximum stress <24,625 psi						
Edge	-1.00	---	---	2.9	3.3	3.4
Fillet	-1.00	---	---	2.4	2.6	2.8
Edge	-.50	---	---	3.0	3.2	3.5
Fillet	-.50	---	---	---	2.6	2.8

TABLE 14.- VALUES OF K_N FOR SEVERAL

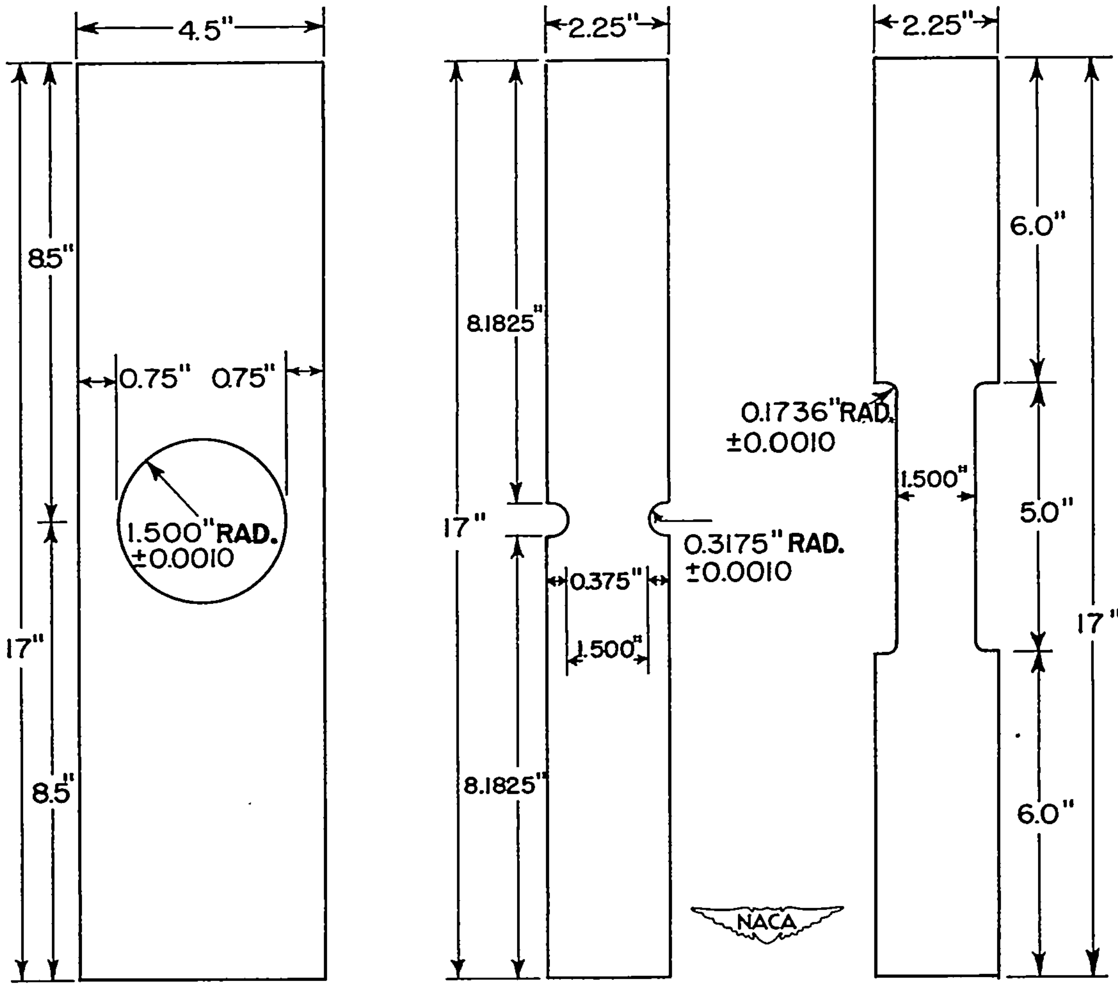
ASSUMED VALUES OF ρ'

Type of Notch	K_t	Radius, ρ (in.)	Value[1] of Neuber's "technical stress-concentration factor," K_N, for -			
			ρ' = 0.02 in.	ρ' = 0.01 in.	ρ' = 0.005 in.	ρ' = 0.001 in.
Hole	2	1.5000	1.90	1.95	1.95	1.95
Edge	2	.3175	1.80	1.85	1.90	1.95
Fillet	2	.1736	1.75	1.80	1.85	1.95
Edge	4	.0570	2.90	3.10	3.30	3.65
Fillet	4	.0195	2.50	2.75	3.00	3.45

[1]Computed, to the nearest 0.05, from the relation:

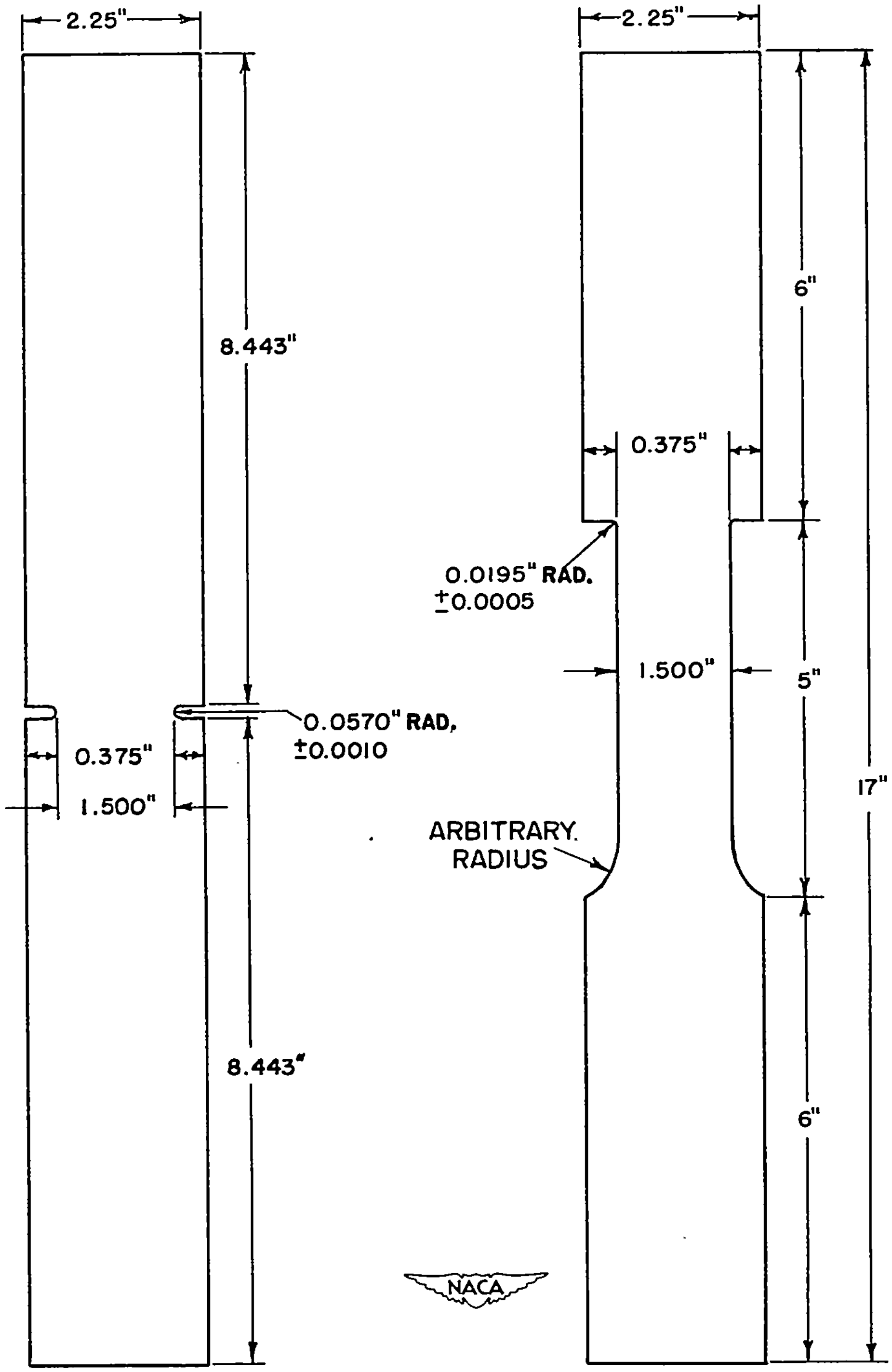
$$K_N = 1 + \frac{K_t - 1}{1 + \sqrt{\rho'/\rho}}$$

Neuber suggests ρ' = 0.0189 in.



(a) Hole-type notch. (b) Edge-cut notch. (c) Fillet-type notch.

Figure 1.- Notched fatigue test specimens with $K_t = 2.0$.



(a) Edge-cut notch. (b) Fillet-type notch.

Figure 2.- Notched fatigue test specimens with $K_t = 4.0$.

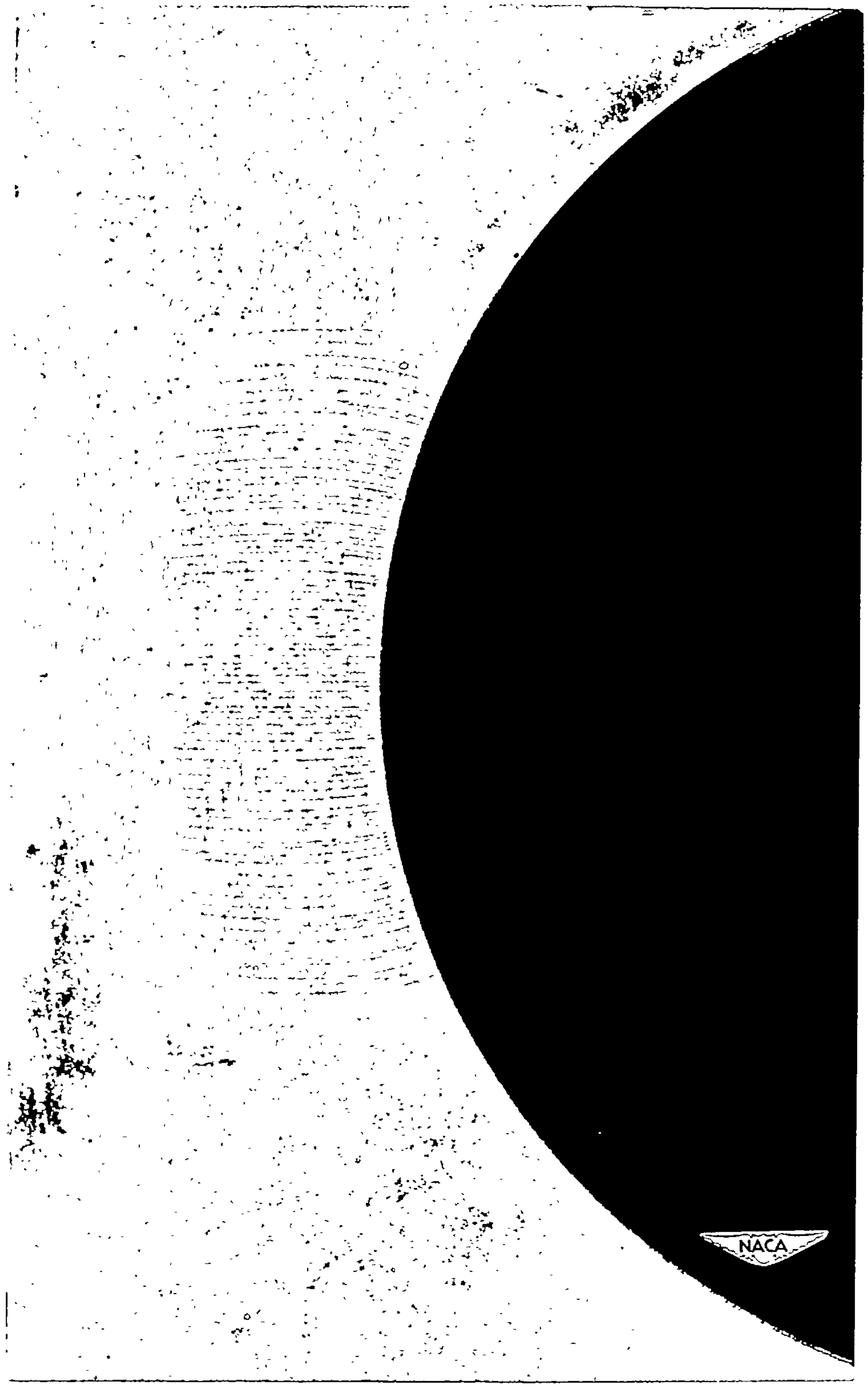
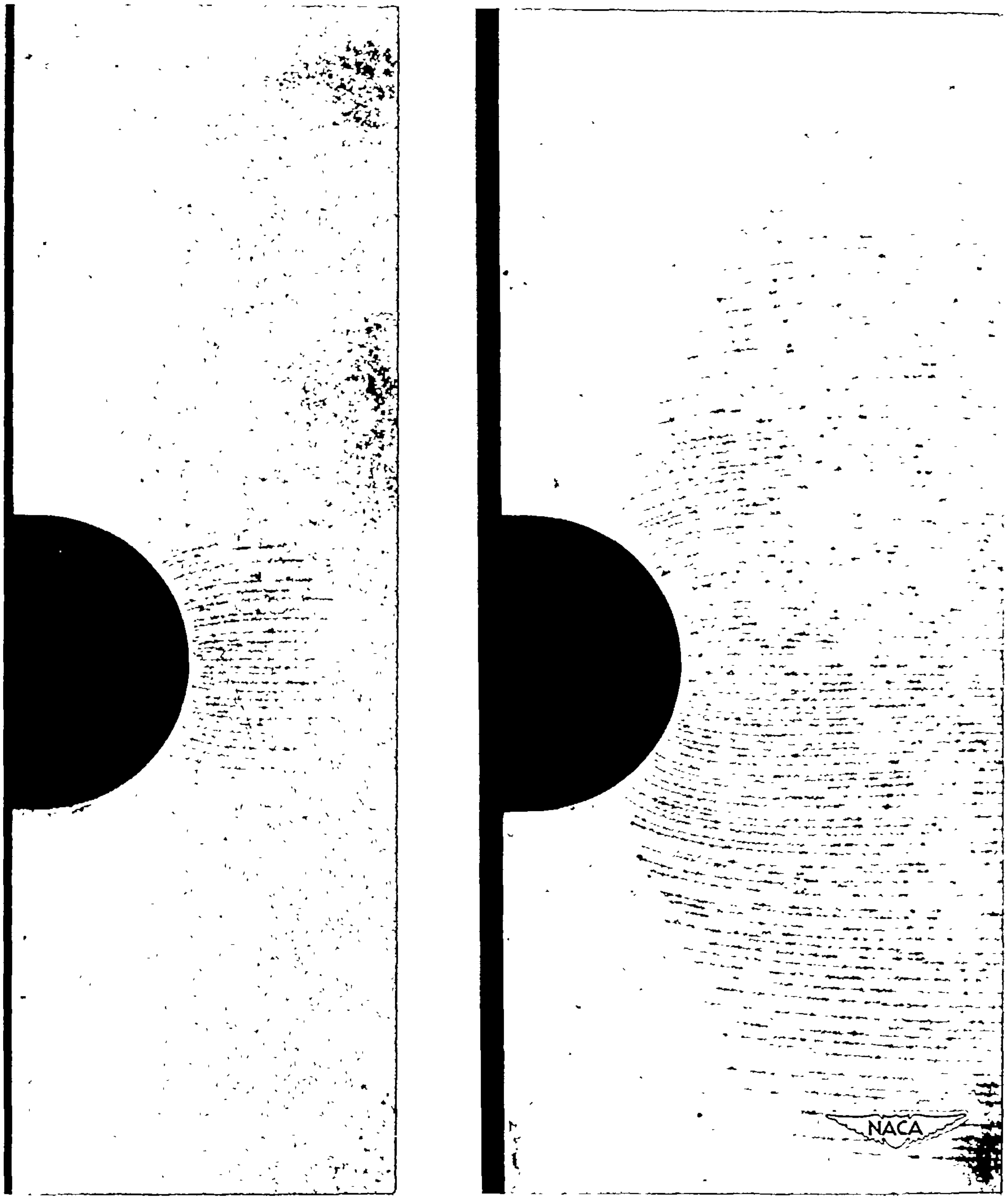


Figure 3.- Stress-coat pattern obtained at approximately 15,000 psi. Nominal loading of hole-type notch. $K_t = 2.0$. Approximately 3X.



(a) At approximately 30,000 psi, nominal.

(b) At approximately 40,000 psi, nominal.

Figure 4.- Stress-coat patterns obtained on edge-cut notch. $K_t = 2.0$. Approximately 3X.

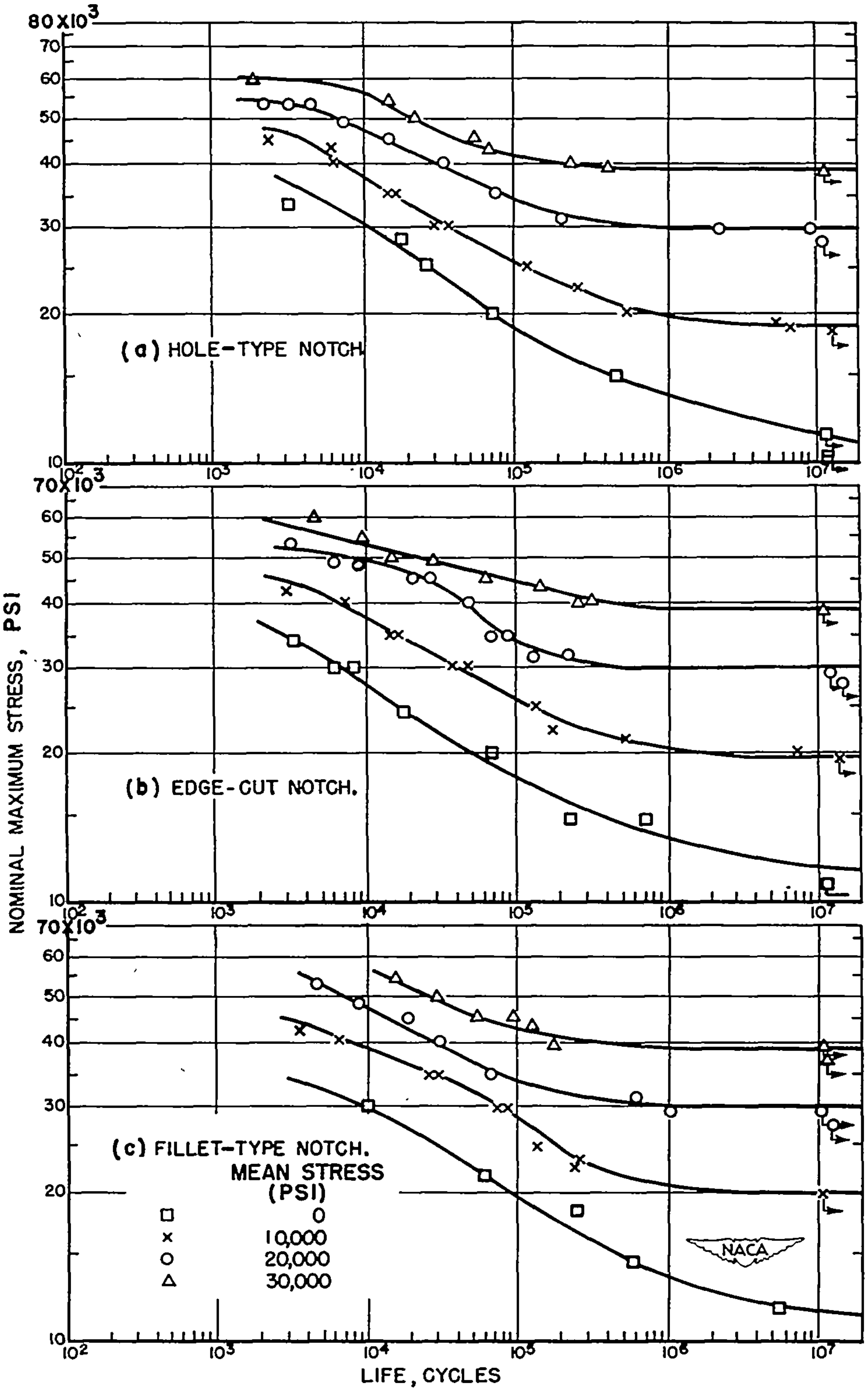


Figure 5.- Results of axial-load fatigue tests on notched 24S-T3 aluminum sheet specimens. $K_t = 2.0$.

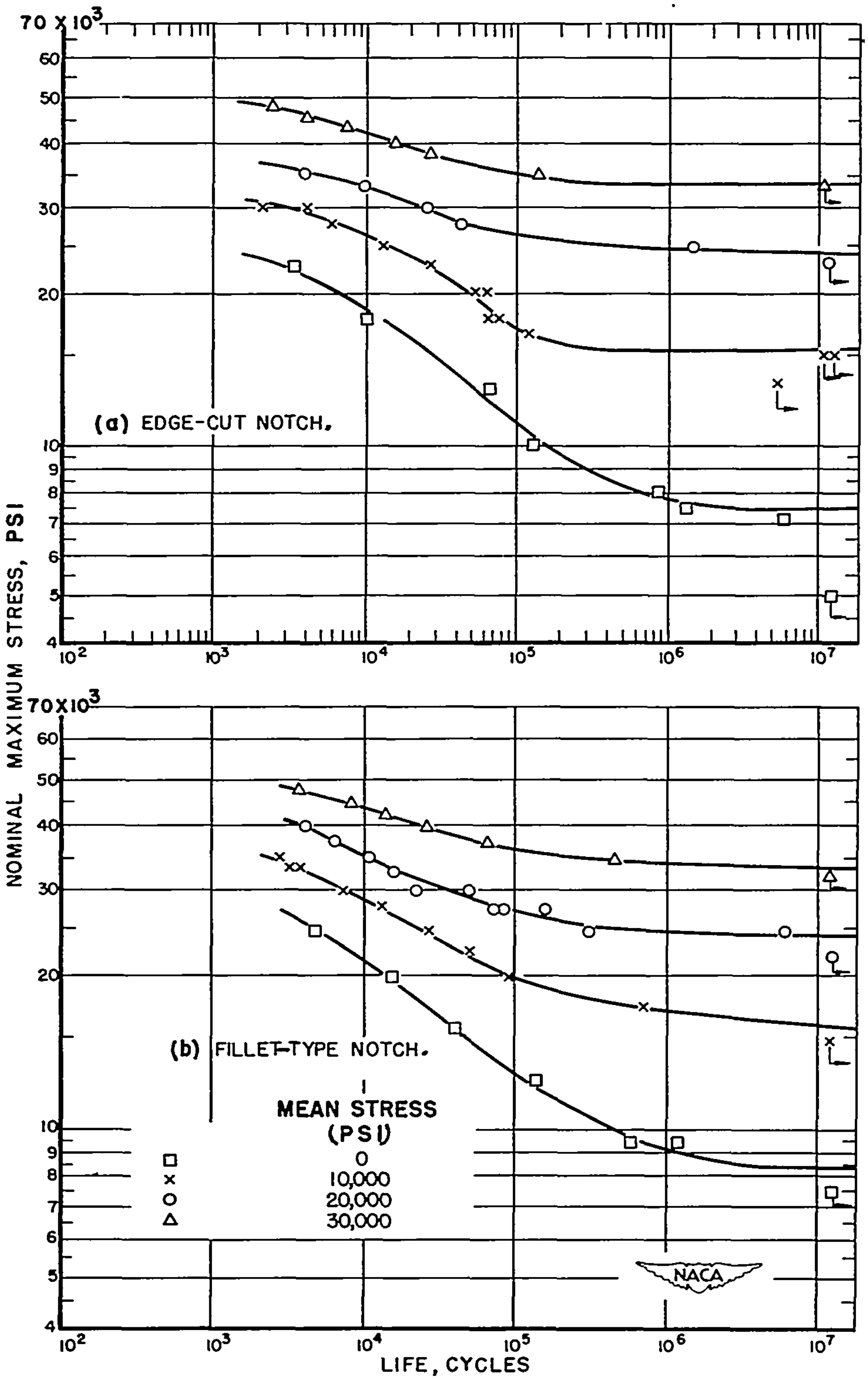


Figure 6.- Results of axial-load fatigue tests on notched 24S-T3 aluminum sheet specimens. $K_t = 4.0$.

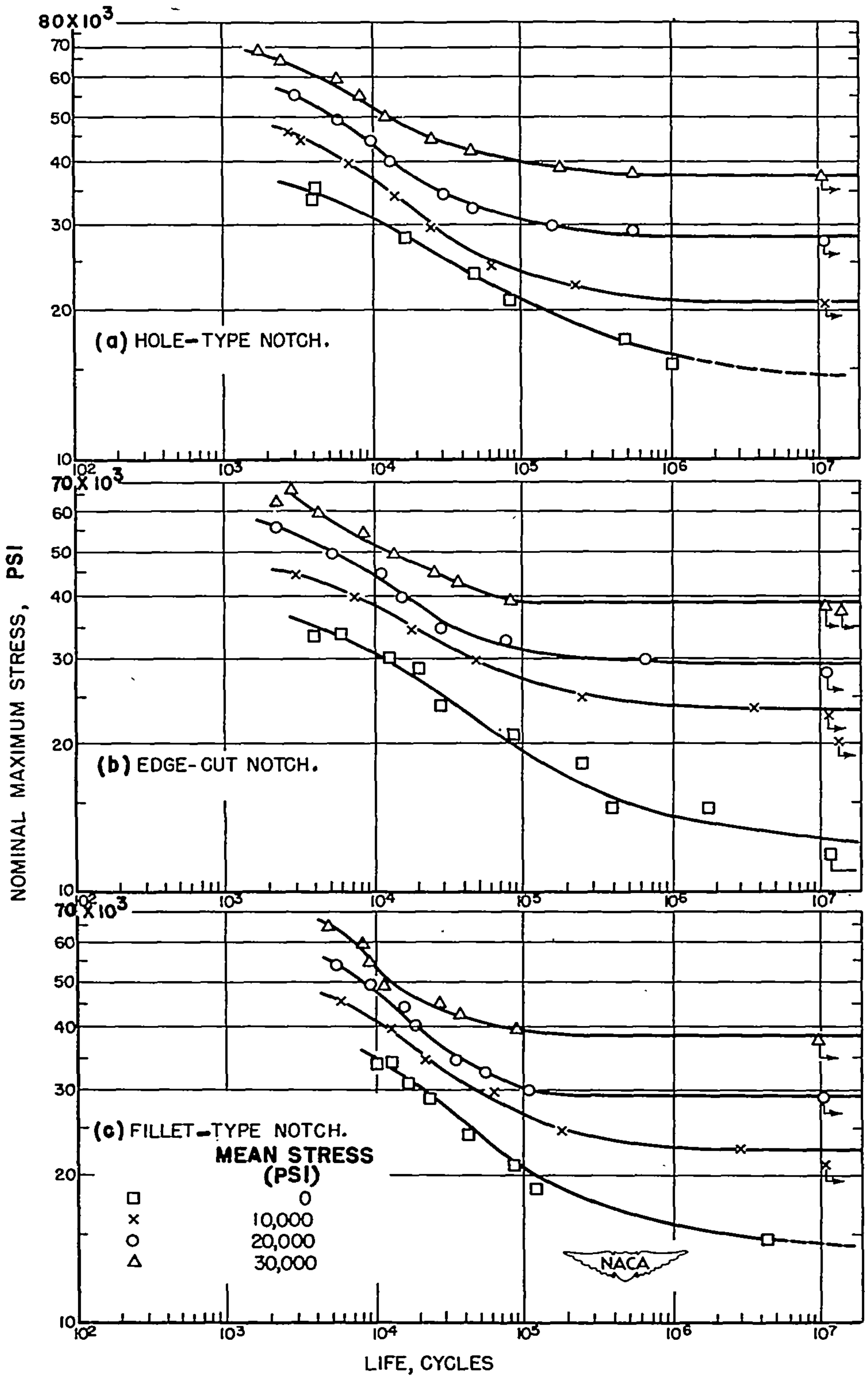


Figure 7.- Results of axial-load fatigue tests on notched 75S-T6 aluminum sheet specimens. $K_t = 2.0$.

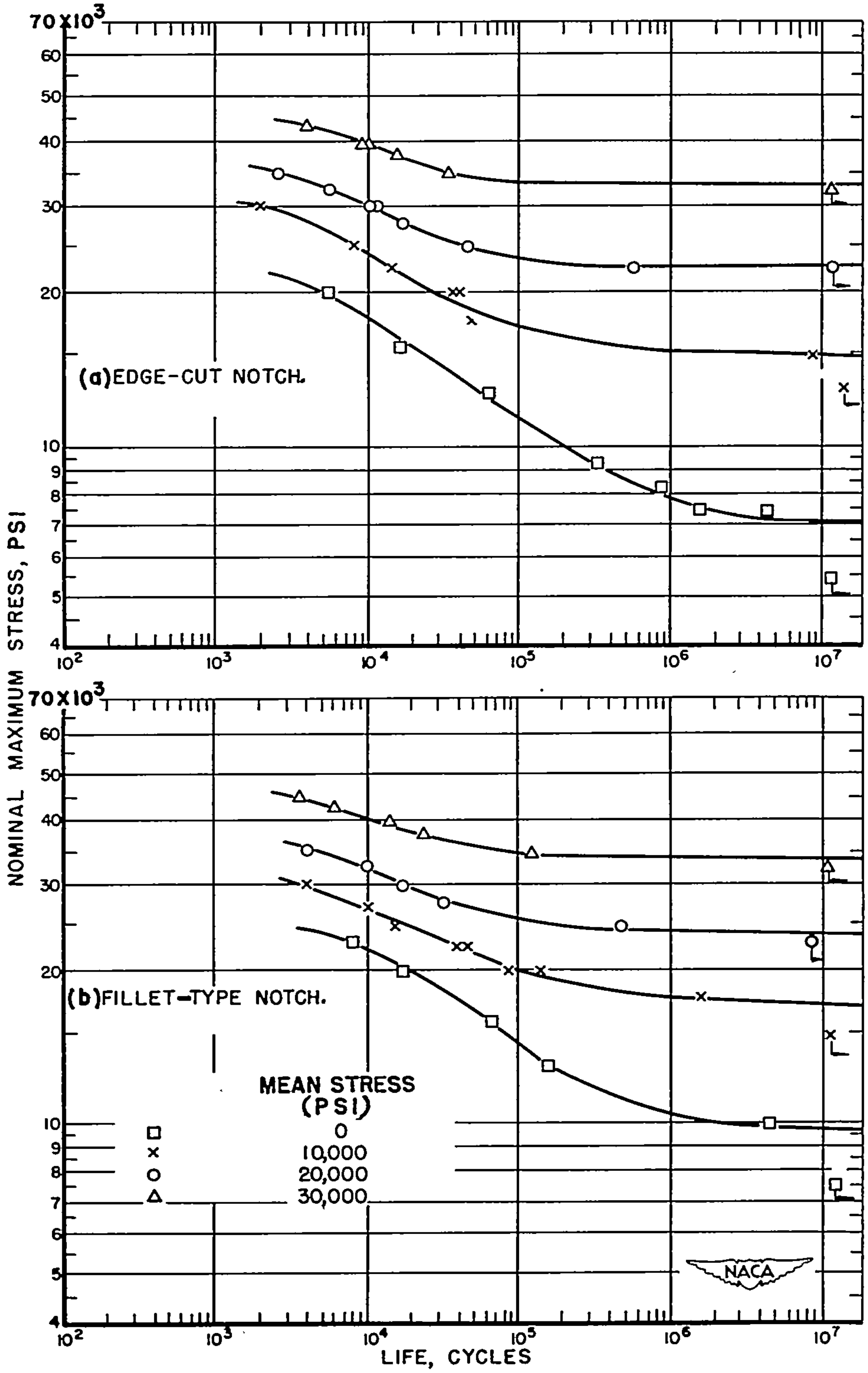


Figure 8.- Results of axial-load fatigue tests on notched 75S-T6 aluminum sheet specimens. $K_t = 4.0$.

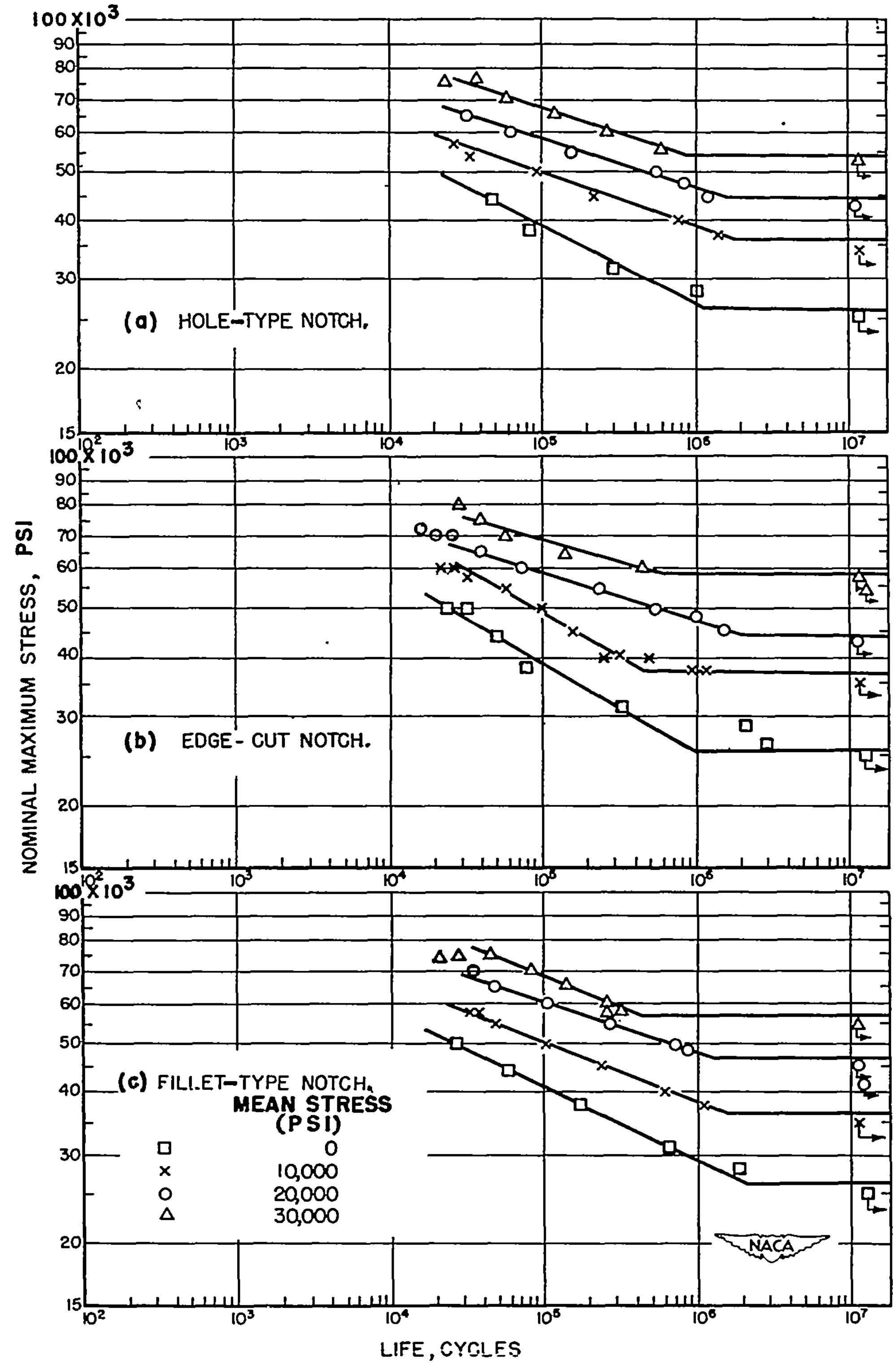


Figure 9.- Results of axial-load fatigue tests on notched SAE 4130 steel sheet specimens. $K_t = 2.0$.

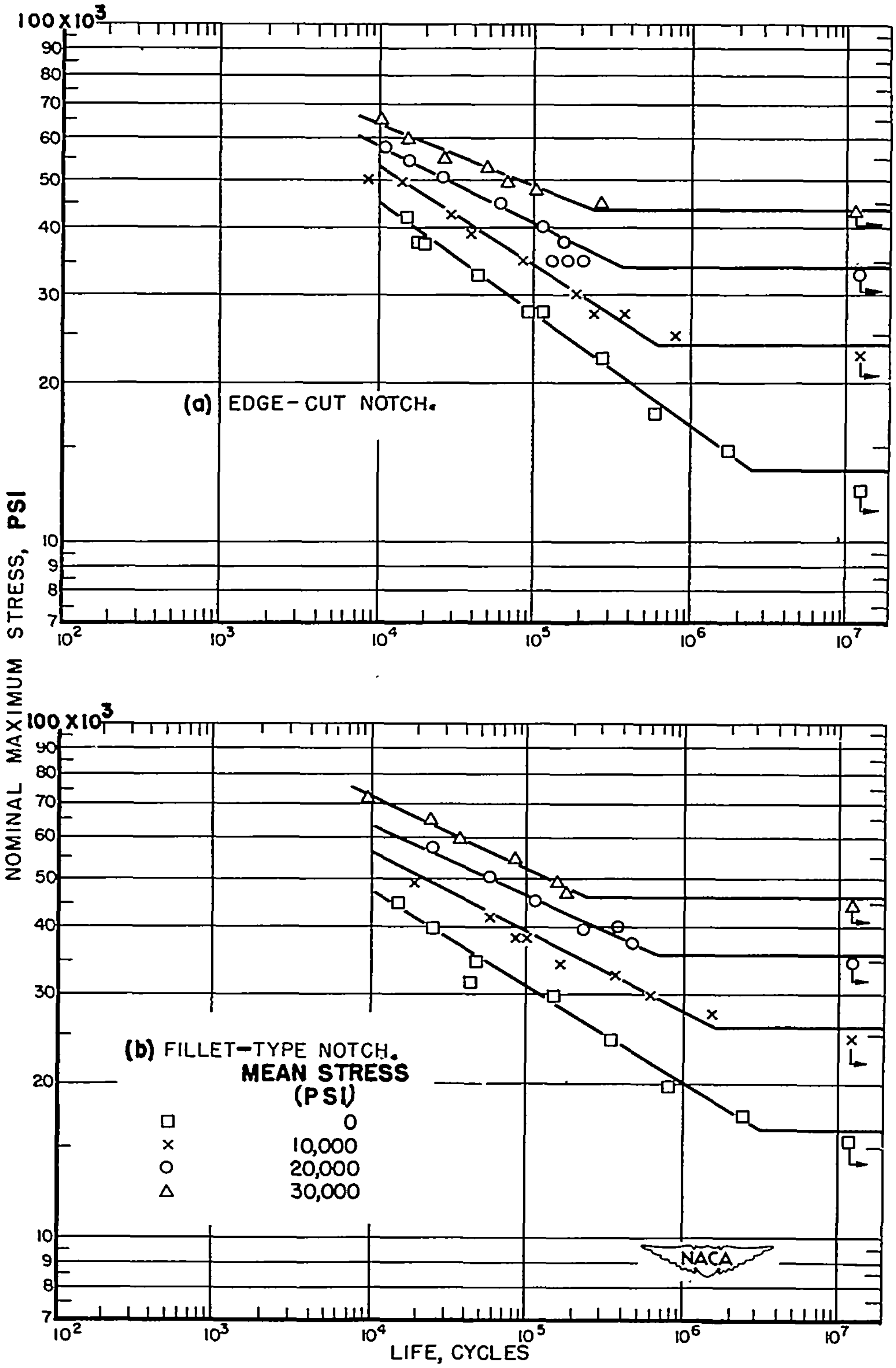


Figure 10.- Results of axial-load fatigue tests on notched SAE 4130 steel sheet specimens. $K_t = 4.0$.

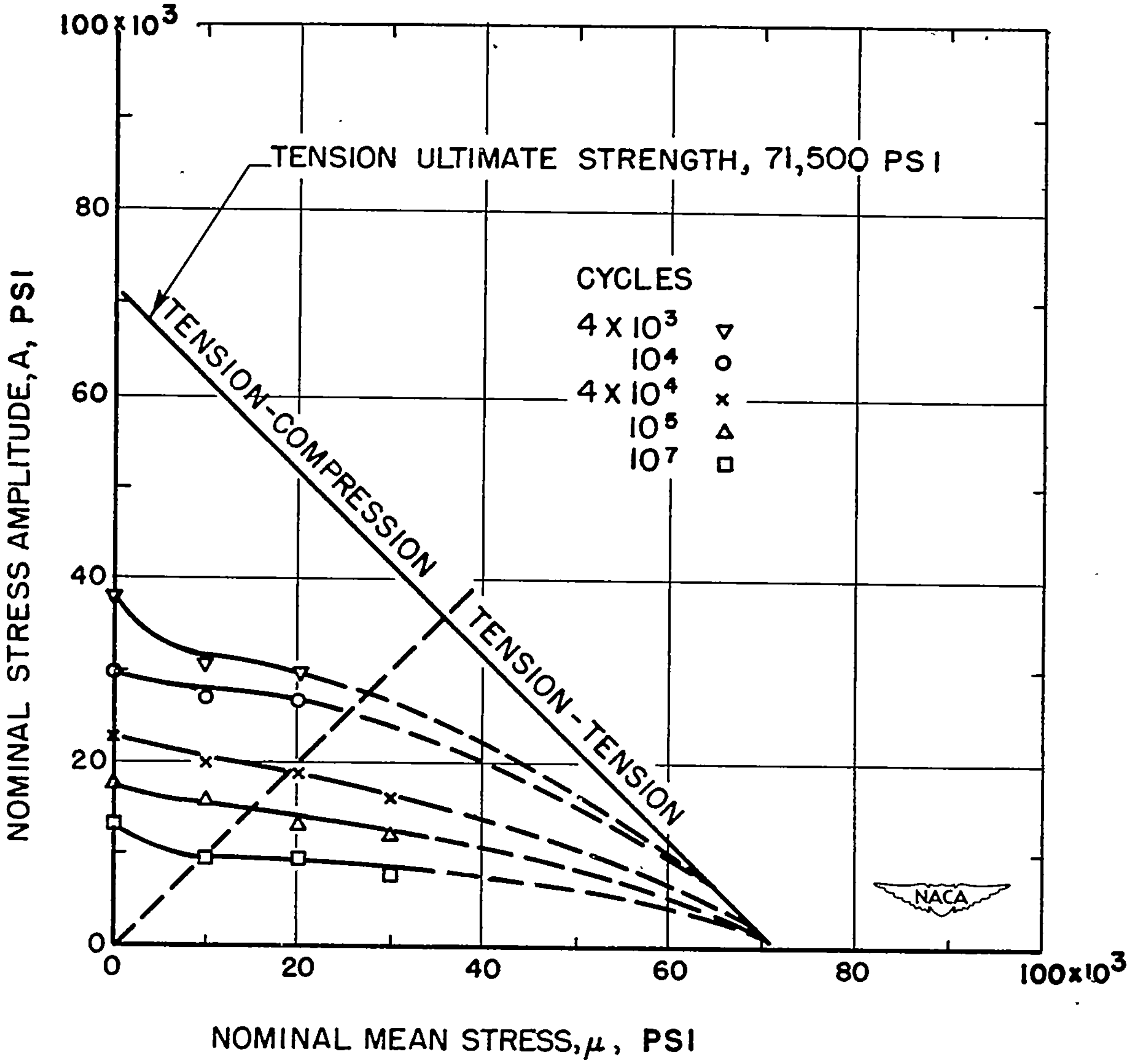


Figure 11.- Constant-lifetime curves for 24S-T3 aluminum sheet notched with a central hole. $K_t = 2.0$.

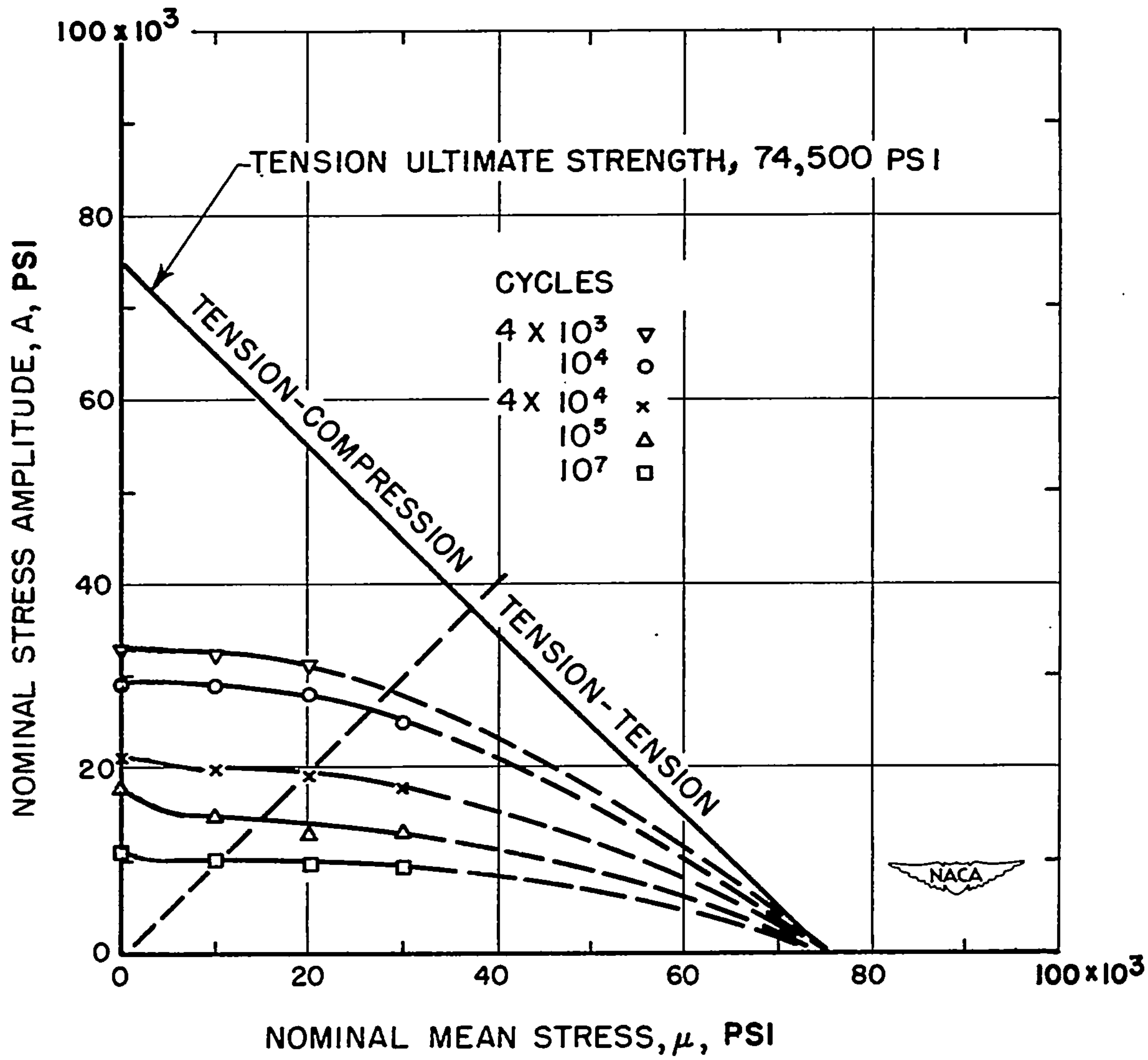


Figure 12.- Constant-lifetime curves for 24S-T3 aluminum sheet notched with symmetrical edge cuts. $K_t = 2.0$.

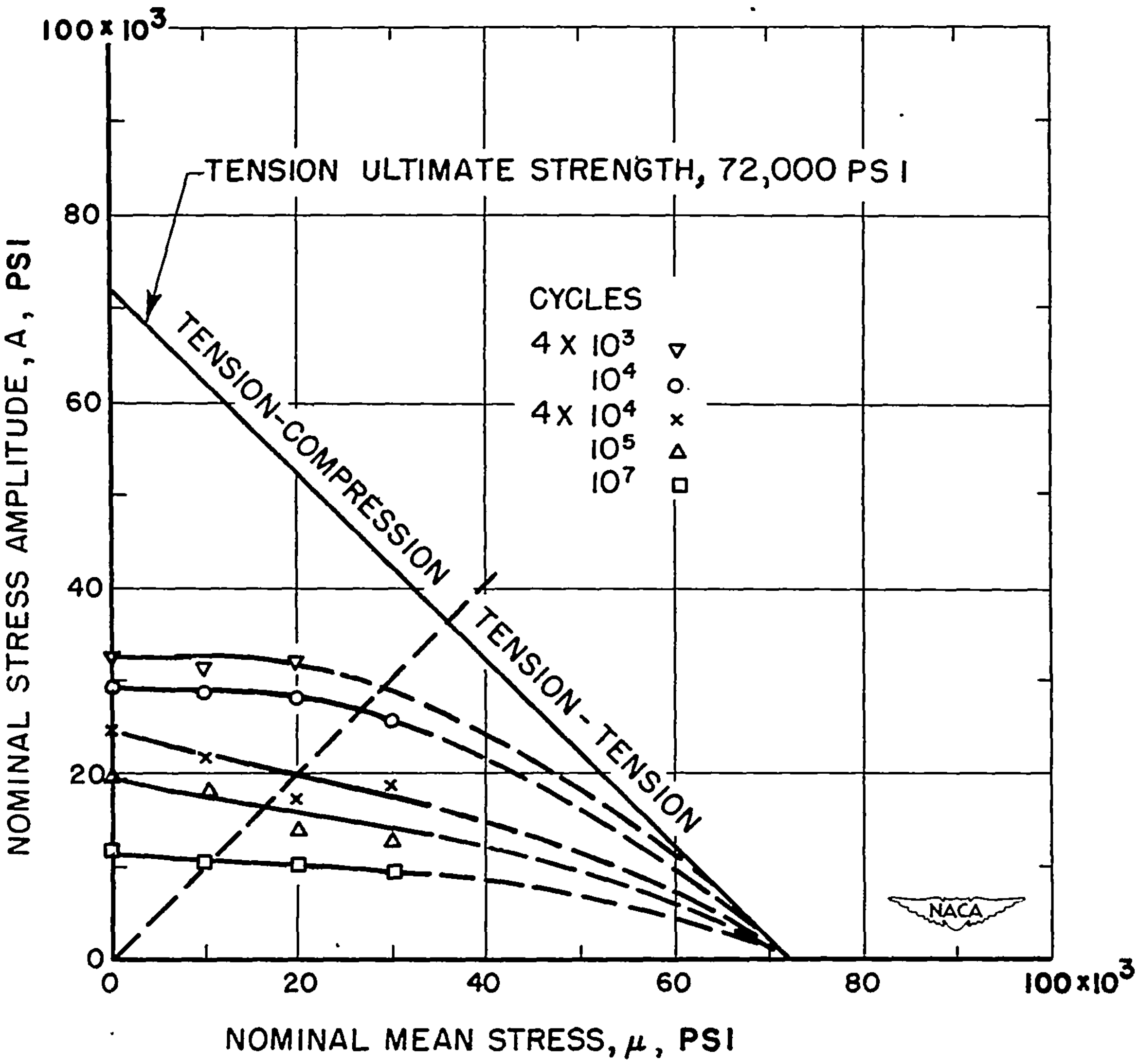


Figure 13.- Constant-lifetime curves for 24S-T3 aluminum sheet notched with symmetrical fillets. $K_t = 2.0$.

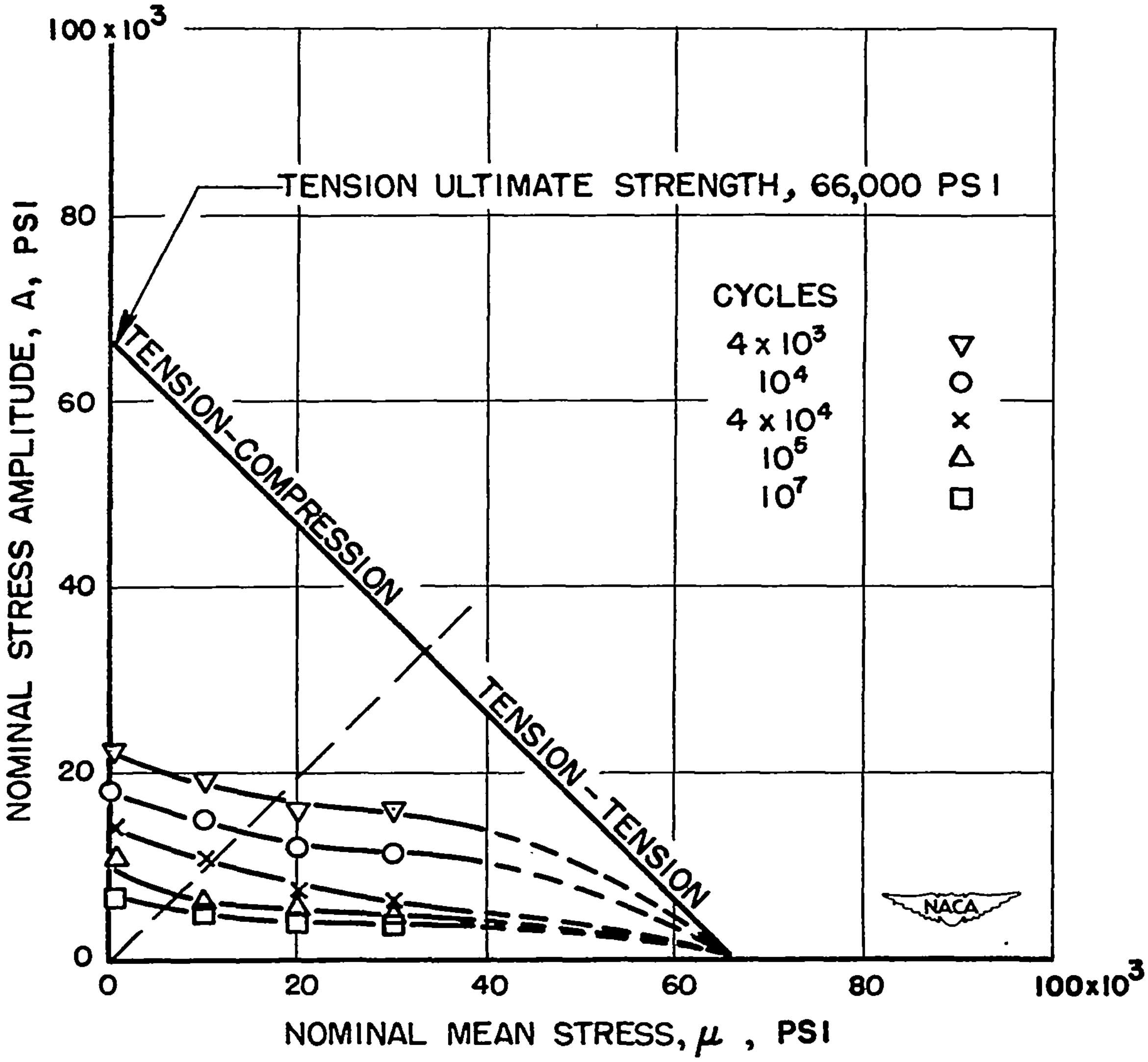


Figure 14.- Constant-lifetime curves for 24S-T3 aluminum sheet notched with symmetrical edge cuts. $K_t = 4.0$.

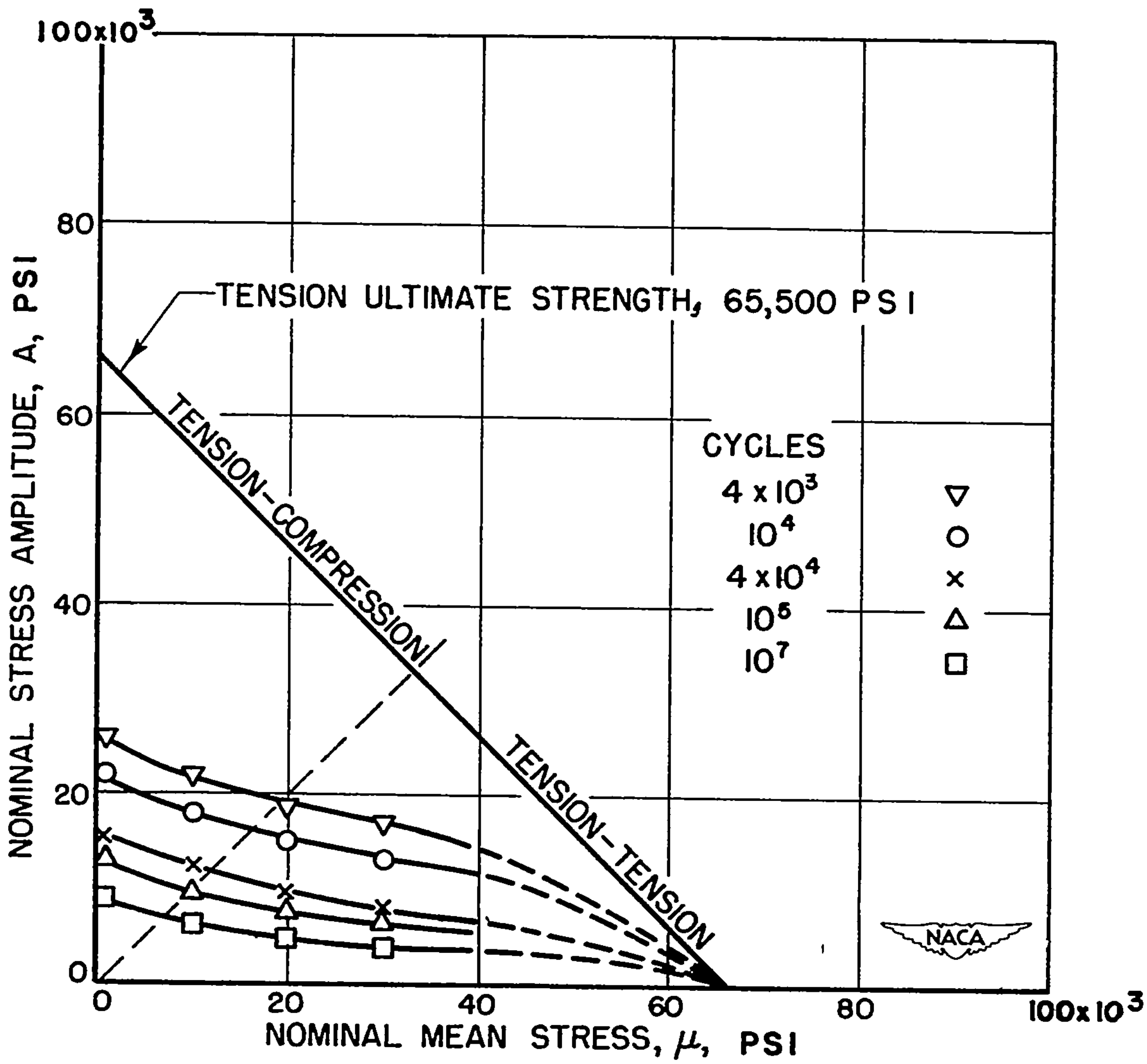


Figure 15.- Constant-lifetime curves for 24S-T3 aluminum sheet notched with symmetrical fillets. $K_t = 4.0$.

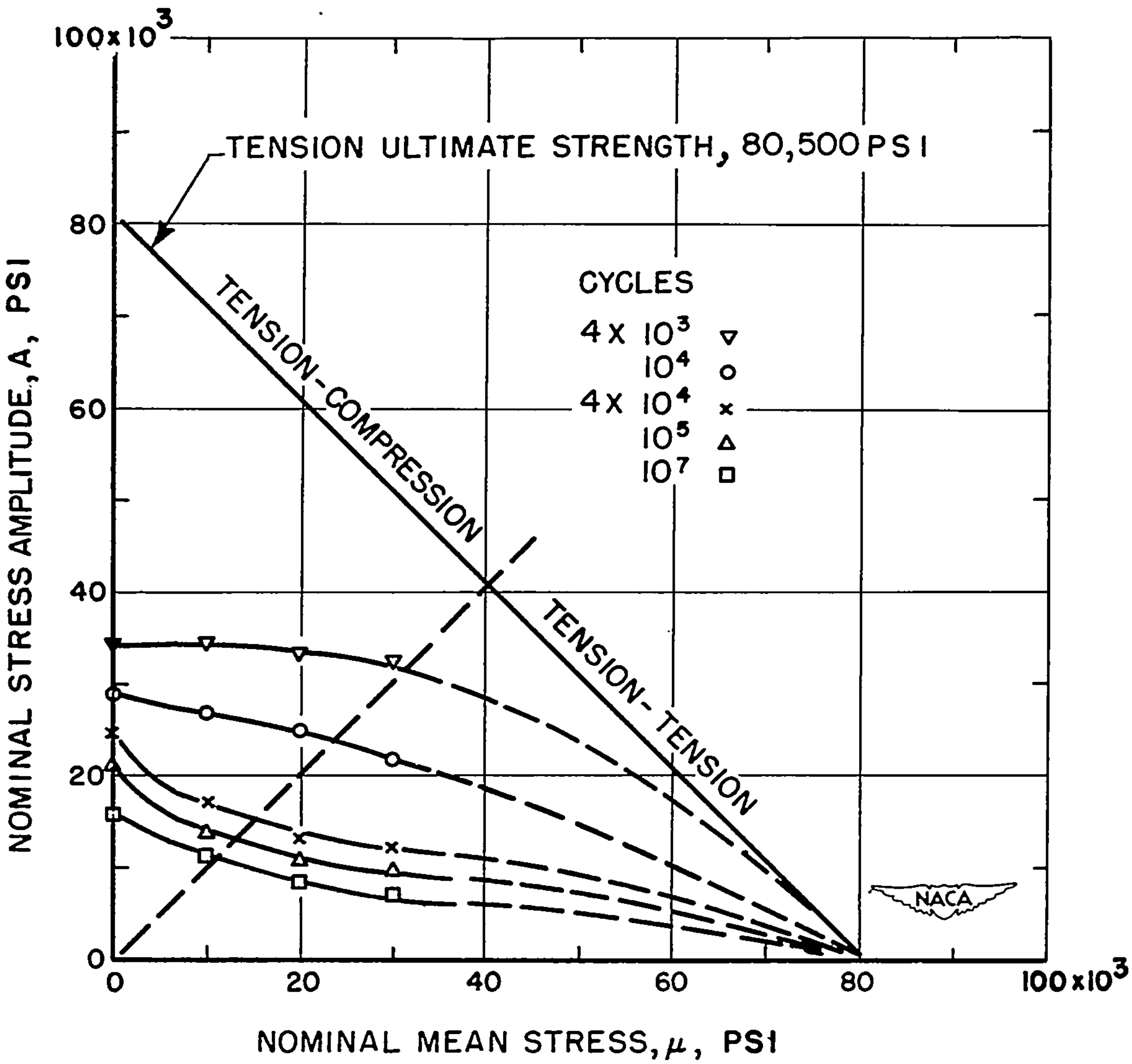


Figure 16.- Constant-lifetime curves for 75S-T6 aluminum sheet notched with a central hole. $K_t = 2.0$.

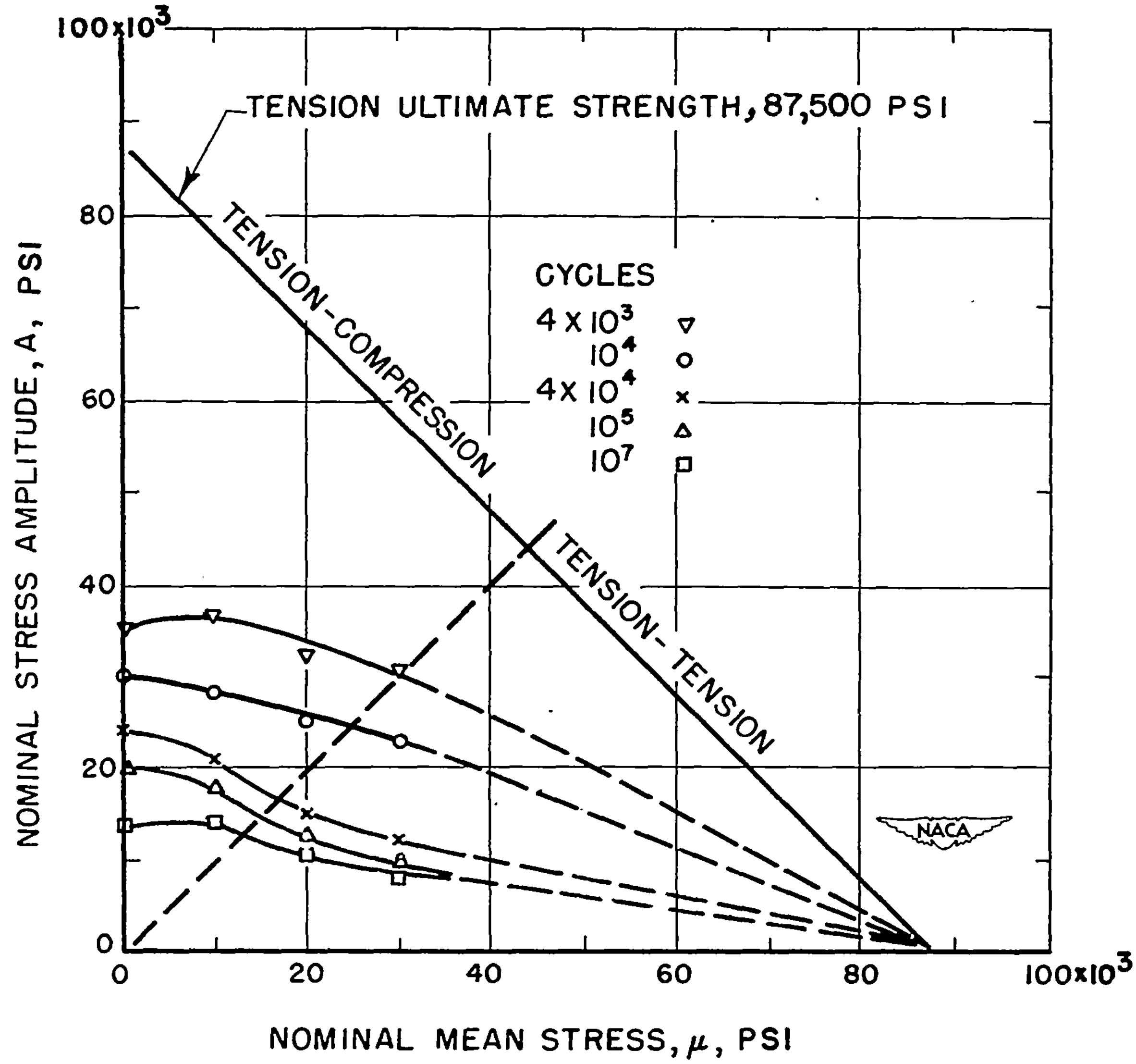


Figure 17.- Constant-lifetime curves for 75S-T6 aluminum notched with symmetrical edge cuts. $K_t = 2.0$.

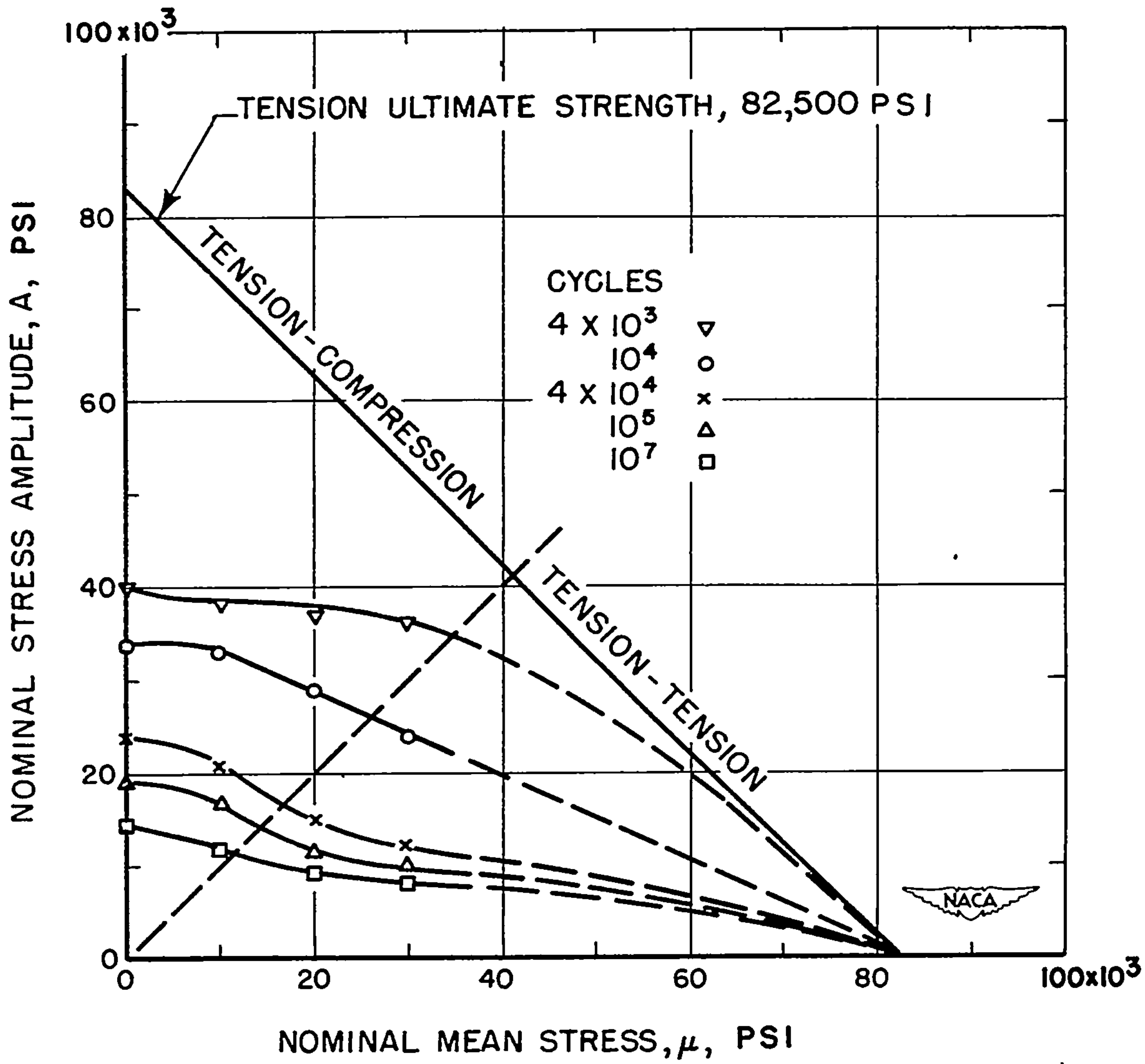


Figure 18.- Constant-lifetime curves for 75S-T6 aluminum sheet notched with symmetrical fillets. $K_t = 2.0$.

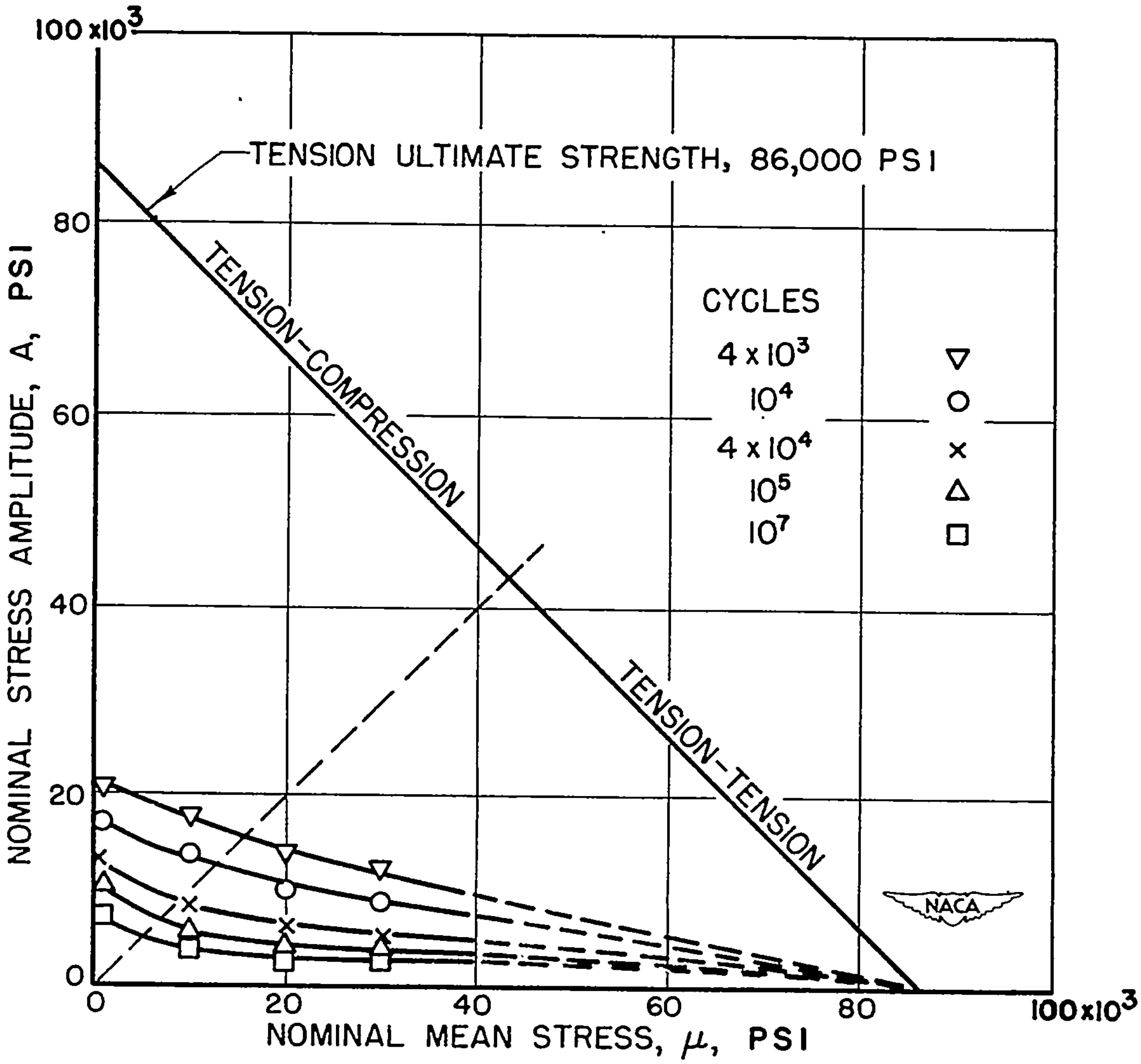


Figure 19.- Constant-lifetime curves for 75S-T6 aluminum sheet notched with symmetrical edge cuts. $K_t = 4.0$.

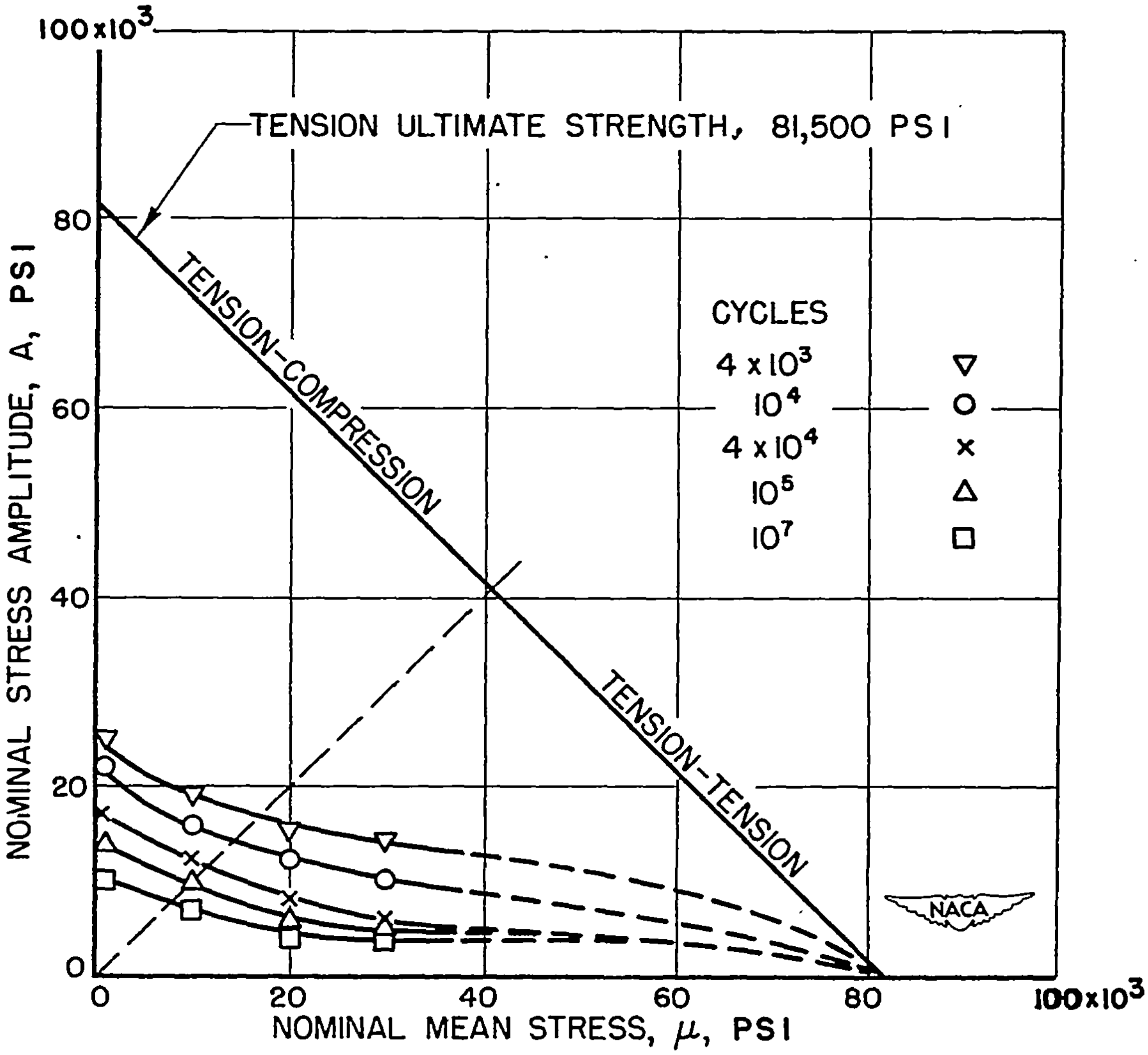


Figure 20.- Constant-lifetime curves for 75S-T6 aluminum sheet notched with symmetrical fillets. $K_t = 4.0$.

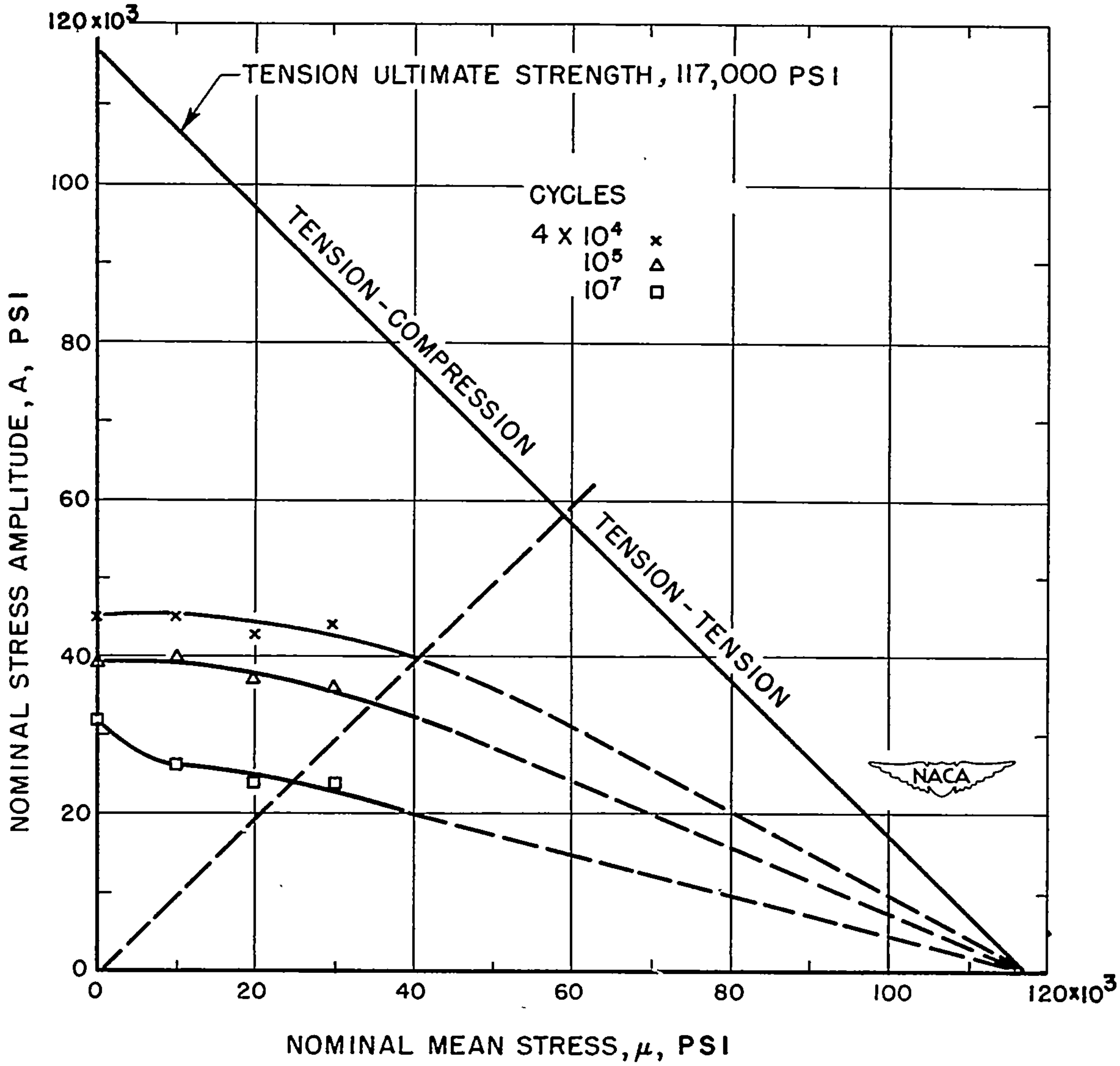


Figure 21.- Constant-lifetime curves for SAE 4130 steel sheet notched with a central hole. $K_t = 2.0$.

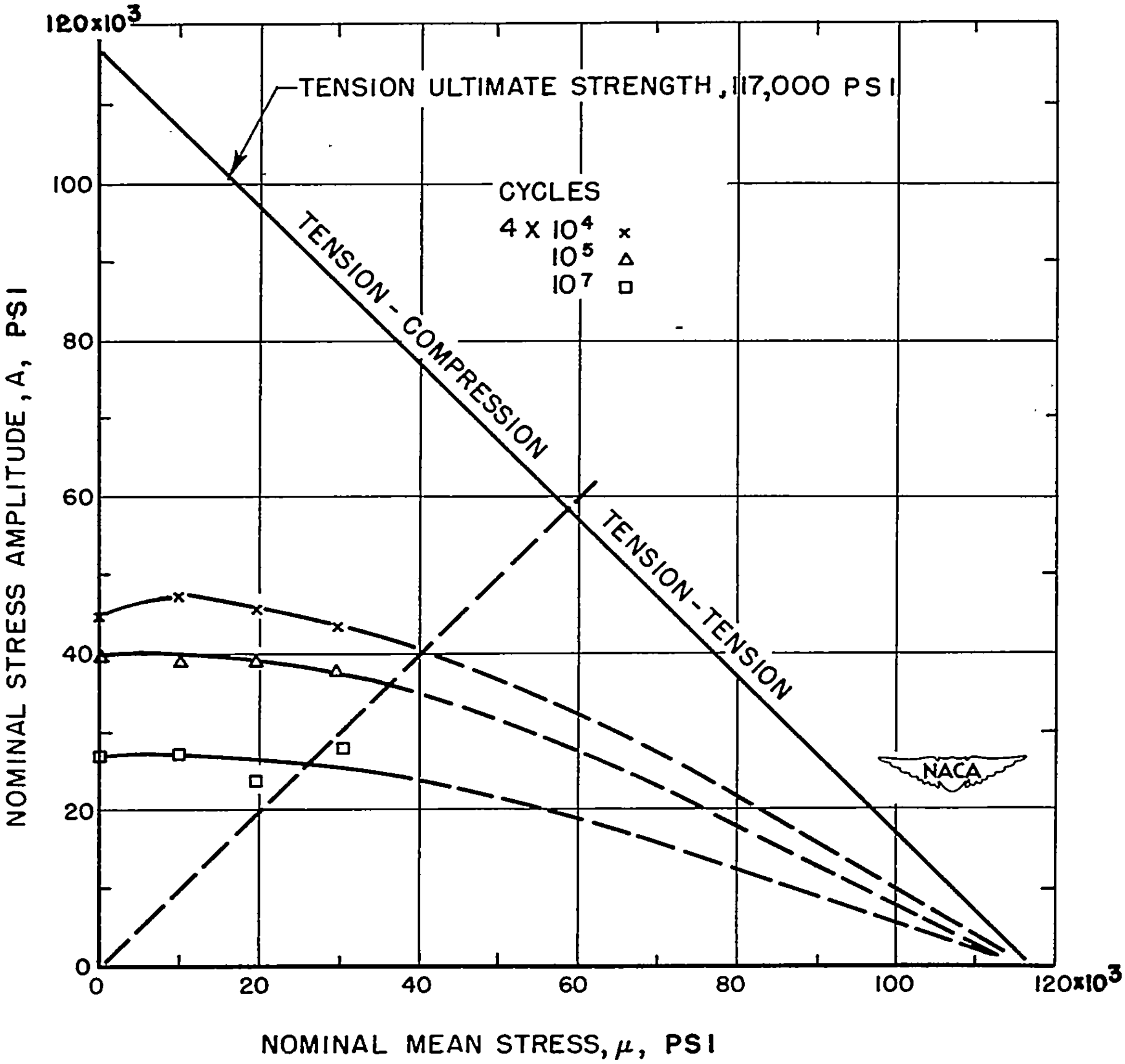


Figure 22.- Constant-lifetime curves for SAE 4130 steel sheet notched with symmetrical edge cuts. $K_t = 2.0$.

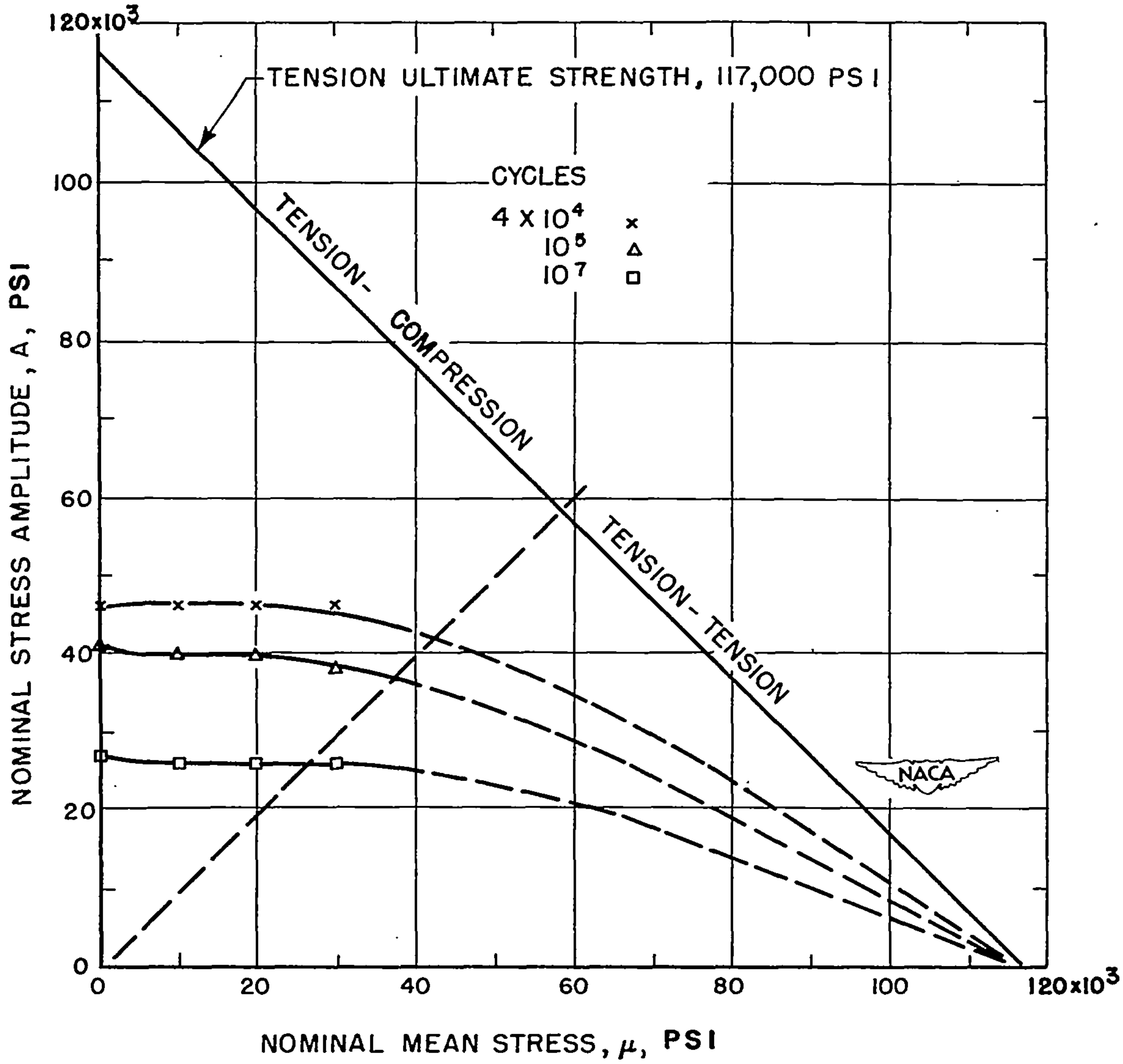


Figure 23.- Constant-lifetime curves for SAE 4130 steel sheet notched with symmetrical fillets. $K_t = 2.0$.

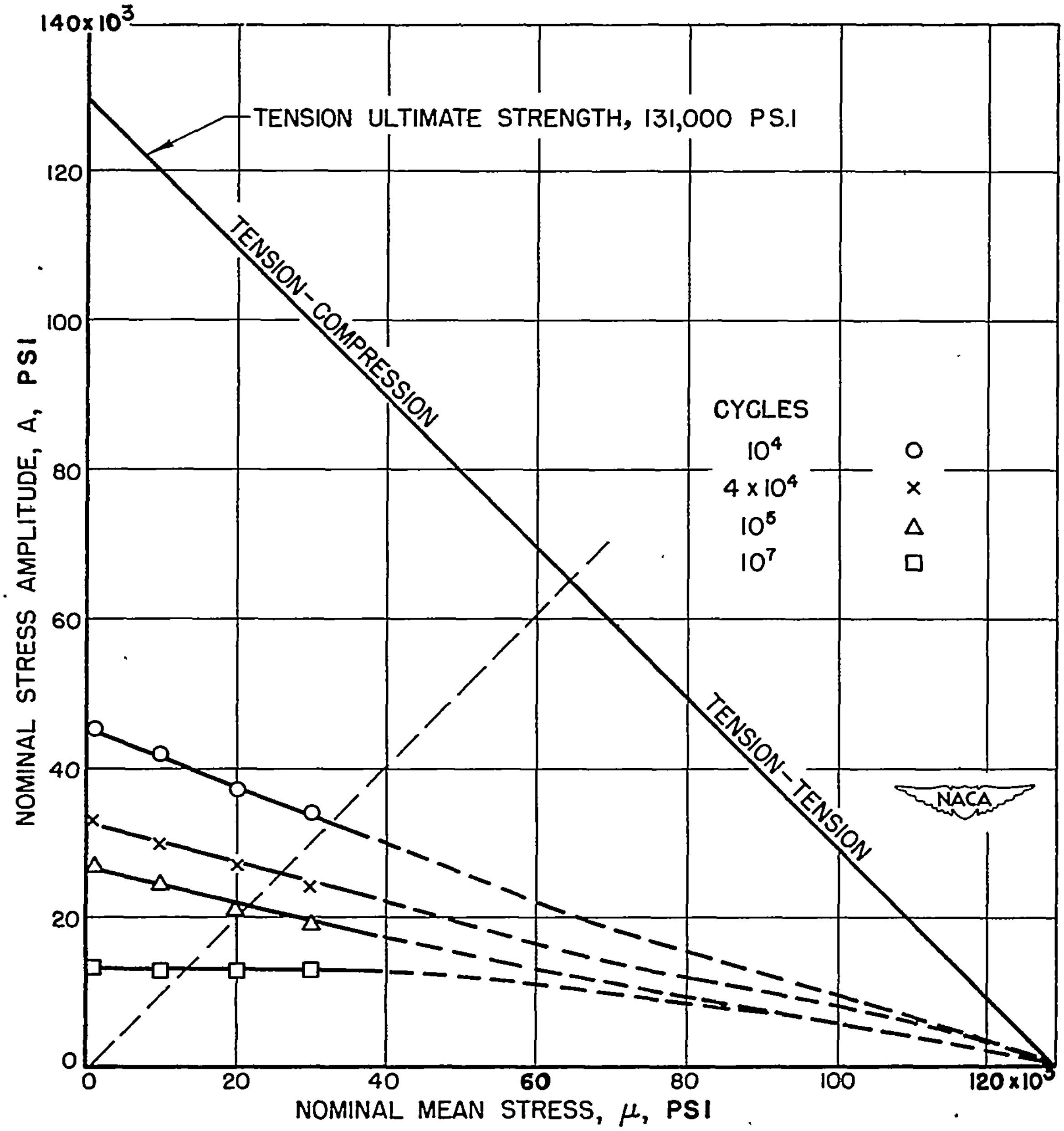


Figure 24.- Constant-lifetime curves for SAE 4130 steel sheet notched with symmetrical edge cuts. $K_t = 4.0$.

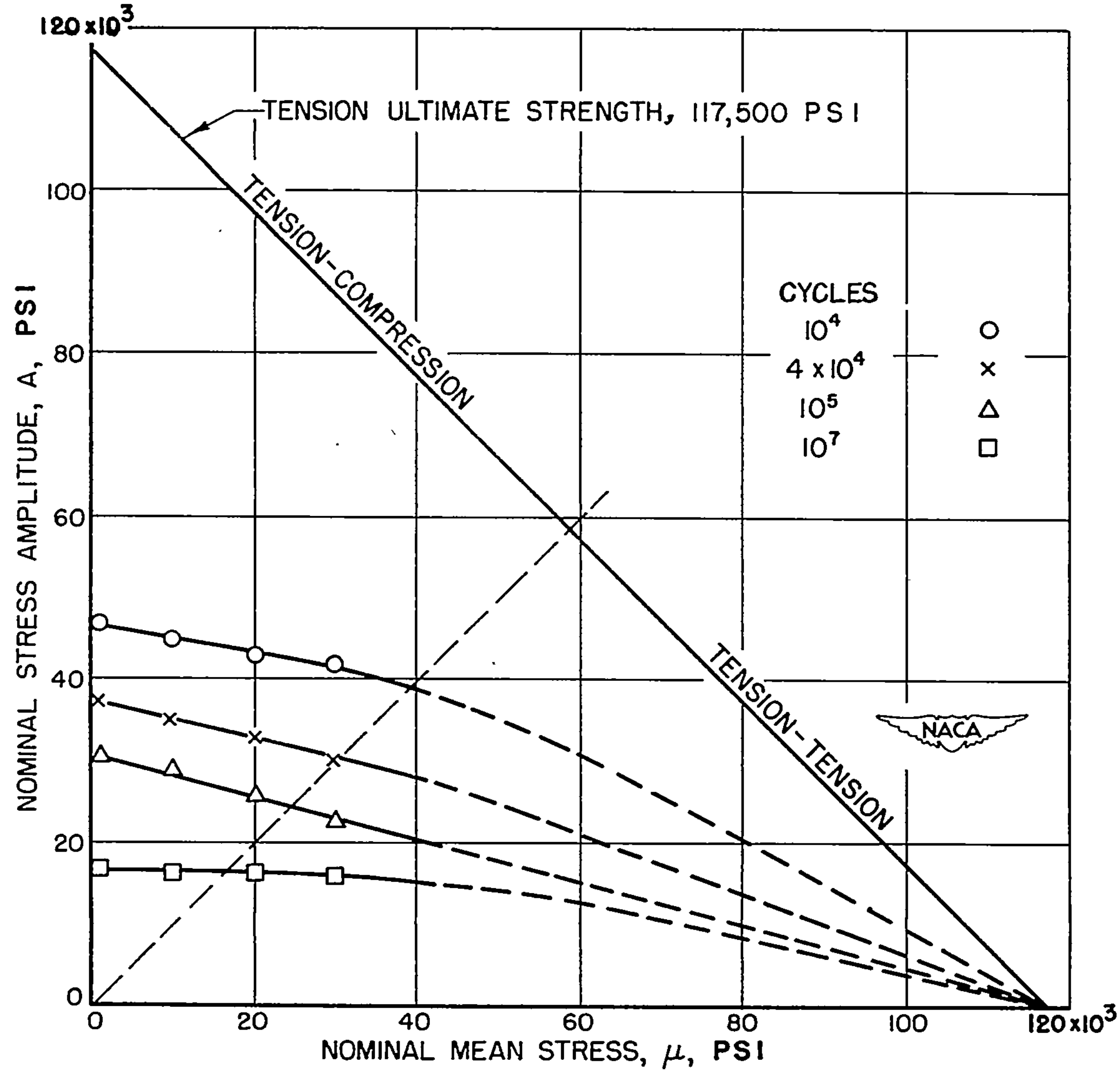


Figure 25.- Constant-lifetime curves for SAE 4130 steel sheet notched with symmetrical fillets. $K_t = 4.0$.

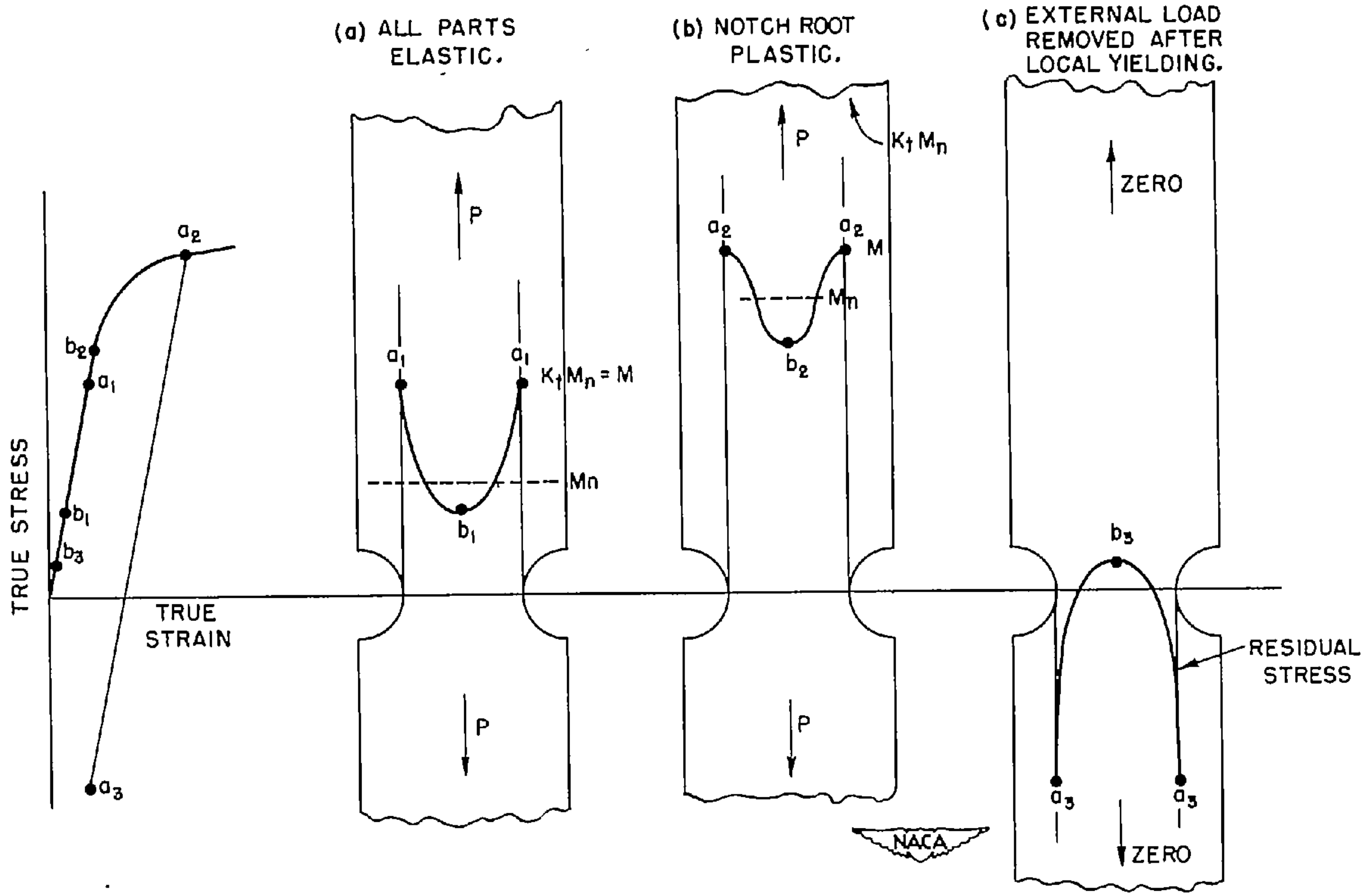


Figure 26.- Schematic representation of stress distribution in a notched specimen at various levels of applied stress. K_t, theoretical stress-concentration factor; M, peak stress; M_n, maximum nominal stress; a_1, a_2, a_3, b_1, b_2, b_3, stresses over cross section.

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